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INCENTIVES IN INDUSTRY

THE volume in which Dr. Elton Mayo discusses some of the social implications of scientific and technical advance which have been emphasized by the 'clinical studies' of the Department of Industrial Research of the Harvard Graduate School of Business Administration has reached Great Britain at an opportune time*. Already the necessity of finding new and adequate incentives, in conditions in which man-power and woman-power fall far short of demand and in which increase of productivity is urgent and imperative, has compelled the Government as well as both sides of industry to look closely at problems which have been neglected too long. Simultaneously, the outbreak of a succession of unofficial strikes points to the need for an overhaul of the structure and functions of the trade unions, so as to ensure closer contact between their officials and the rank and file of their membership, as well as a more effective contribution to the welfare of society. The importance of the last point is further stressed by the extent to which the nationalization of industry is changing the broad aspect of relations between employees and employers and the State, and making the strike weapon both archaic and an anti-social sectional weapon endangering the whole fabric of democracy.

Prof. Mayo's main theme is the importance of the group and of methods of understanding not merely the behaviour of individuals but also groups, whether formally organised and recognized by management, or self-constituted informal organisations ; and his book brings to the forefront the problem of securing group collaboration in the essential activities of industry. In doing this, he lays bare even more fundamental issues than Dubreuil did in his study of the autonomous group, for Prof. Mayo is alive to the wider social implications of the impact of applied science ; and in spite of some assumptions in the economic sphere, due partly to failure to define his terms, which the economist may find irritating, he has given us a book that should assist the creative thought demanded in the present situation He recognizes by implication that industry alone cannot achieve full success : there is a political aspect and an indispensable Government contribution, which he appears to contemplate discussing in a third volume. Meanwhile, he has made a valuable contribution to the educational work to be done both within industry and in the universities and technical colleges, as well as to the study of management problems themselves. His book has claims on the attention of all those concerned with the preservation of a free society, the conditions of which he delineates as three-fold : first, a sufficiently general standard of technical skill and literacy ; secondly, the absence of extreme differences in the material standards of living of its various social groups ; and thirdly, the elimination of internal group hostilities and hatreds.

* The Social Problems of an Industrial Civilization. By Prof. Elton Mayo. Pp. xvii+150. (Boston, Mass. : Graduate School of Business Administration, Harvard University, 1945.) 2.50 dollars.

It needs no more than the most superficial glance at the events of the past year to realize that although the whole trend of policy in Great Britain during the past decade has been towards the levelling of the differences in material standards of living, the second and third conditions are as yet by no means fulfilled. Behind the recent strikes lies a question of the quality of citizenship which is only partly a trade union matter; and which is of increasing importance as more and more industry passes within the orbit, if not directly of the State itself, at least indirectly in the public corporations. Moreover, the declining level of general intelligence which Sir Cyril Burt's recent study has indicated makes it imperative that more attention should be given to this factor of education, and there is as yet little evidence from the men returning to civil life from the Services that the educational work in the Forces has proved effective in raising the level of understanding of the meaning and responsibilities of citizenship.

Increasingly we are coming to realize the searching demands that a democratic society makes of its citizens; and the supreme reason for seeking urgently and imperatively to eliminate the divisions due to group hostilities is that they present a fatal obstacle to effective participation and co-operation both within industry and also at the international level. Effective co-operation is the condition of industrial efficiency and higher productivity in Britain, just as much as it is the condition for the survival of civilization in the international sphere. Civilization, as Prof. Mayo points out, can destroy itself if it fails to understand intelligently and to control the aids and deterrents to co-operation, and his recurrent theme is that if our social skills had advanced step by step with our technical skills, there would not have been a second world war.

In the first of the two essays, "Science and Society", Prof. Mayo urges that collaboration in an industrial society, whether in a political or an industrial unit, cannot be left to chance; but hitherto all our administrative methods have been aimed at securing satisfaction of material and economic needs, and not at the equally important problem of maintaining spontaneous co-operation. Absenteeism, the turnover of labour, and unofficial strikes testify to our ignorance of how to ensure the spontaneity of co-operation, the team-work that was the characteristic of so many outstanding achievements in the scientific and technical field during the War. Moreover, we have passed beyond the stage of human organisation in which effective communication and collaboration were secured by established routines of relationship. As Lewis Mumford has pointed out, we are living in an age when we can no longer assume that the technical processes of manufacture will exist unchanged for long in any type of work.

That, of course, is one reason why conditions of full employment imply greater mobility of the workers and why it is imperative for the trade unions to re-examine their outlook and practice. Adaptability and not restriction is the condition of social security; and the very instability of techniques makes a fuller stability in companionship imperative. We have to acquire new social skills that will be effective in the specific situations, and although this must be in the main a task of management and a major responsibility of all institutions concerned with the training of those destined to occupy positions of leadership, it is a task in which every worker is also concerned. Prof. Mayo undoubtedly puts his finger on the weak spot in suggesting that the outstanding defect of civilization is the incapacity of groups to communicate effectively and intimately with each other.

The defect lies at the root of most of the acute issues developing between managements and workers, and indeed between Government and people, as it often does of the failure of men of science to secure proper appreciation by the administrator of the scientific factors in a situation. Scientific men at least are coming to appreciate more fully that, as Prof. Mayo observes, the development of usable skill must be accompanied by the acceptance of responsibility of one kind or another. The widespread manifestation of a sense of social responsibility in relation to the development of atomic energy which has characterized scientific workers in the United States and in Great Britain during the last eighteen months is possibly one of the most hopeful and healthy signs of recovery on that side.

Prof. Mayo is less happy in his second essay, in which he discusses what he terms the 'rabble hypothesis' and its corollary, the State absolute. He emphasizes in conclusion that the active development of social skill and insight is required to make the forms of democracy come alive, and he returns to this theme in the concluding chapter of the book. He argues that the only way of dealing with the industrial or the international situation is by, first, the patient, pedestrian development of first-hand knowledge; secondly, the development of skill in handling the facts through intimate acquaintance; and thirdly, the clear statement of the logical implications of the effective skill.

Modern civilization, Prof. Mayo urges, is greatly in need of a new type of administrator, who can, metaphorically speaking, stand outside the situation he is studying; and throughout the book his main emphasis lies on the organisation of co-operation, because it is so largely ignored in the universities, in industry and in political statements. Knowledge of the relevant technical skills and of the systematic ordering of operations is indeed essential; but it is to the need for close observation, for the ability to communicate and to listen, and to train students in the study of social situations that he is primarily concerned to direct attention, emphasizing that first-class technical training alone is insufficient in a modern and mechanical age.

The capacity of the individual and of the group to become adapted to new circumstances and to new relations with other people has been made a vital necessity in our adaptive society by the great pace

of modern technical and industrial development; and the most disturbing feature of the present situation is that so few professional organisations, whether trade unions or not, have shown any real appreciation of the fact. It should indeed be a prime purpose of the production committees and works councils to increase this adaptability or flexibility: information is an important means to that end. The attitude indicated in what is generally known as the 'closed shop' policy is most sinister in that it threatens the existence of the very groups which might provide stability; and in so far as the formation of very large trade unions is encouraged for reasons of ease of negotiation, it is vital that within the large union something corresponding to personnel management or public relations should be developed, to ensure real contact and understanding between the national and regional leaders and the local groups and rank and file of the membership.

There follows from this the necessity for developing intensively industrial relations in their widest sense, by either the formation of workers' councils and committees, or the constant provision of full information regarding the purposes of industrial policy to the workers individually and to their organised groups. There is room for effort from both the trade union and the employers' side for initiative in this field, in order to dispel the legacy of distrust which is one obstacle to higher productivity; and the industrial psychologist may well have a vital contribution to make in raising the whole standard of what for want of a better term is known as personnel management. Included in this is the training of leaders at the lower levels of responsibility—the foreman and charge-hand on the part of industry, the shop-steward on the part of the trade unions. If management and trade unions could work out jointly a policy of selecting and training men for such positions in the best interests of industry, from the point of view of the nation, we should have taken a big step towards securing co-operation at the vital level of production and at the same time have assisted in the formation of those very groups which provide the individual with the satisfaction and security he seeks, while linking them to the service of society as a whole.

A wide field exists for further research. We need to know more about the best methods for securing adequate representation from small groups of employees in sections or departments, and for discussions of company policies or procedures prior to their introduction, and information on production, sales, finance, etc. The whole problem of incentives in industry demands a searching re-examination, and new methods are required for bringing up and discussing such matters as 'waiting time', absenteeism, raw material shortages, labour shortages, production targets and the like.

The great value of Prof. Mayo's book is the vivid way in which it indicates the practical possibilities of group co-operation and relates them to the larger problem of the renewal of democracy not merely in industry but also in the world as a whole. It is true that, however urgently they are explored, they cannot bring their full effect to the solution of the immediate problem of increasing productivity, although the very initiation of such investigations might have a profound psychological effect. A similar comment applies to remarks of the Chief Inspector of Factories in his last annual report regarding the need for a general cleansing and refit to bring British factories back to their pre-war standard, and the introduction of more light and colour to brighten them up and take them a step beyond; all this clearly depends on factors outside the control of industry itself. Shortages of labour, materials and plant—not to mention difficulties in the way of obtaining the necessary permits—undoubtedly hinder or prevent the use of such means of increasing industrial efficiency; nevertheless, it is important to recognize and acknowledge their significance in promoting better relations in industry.

Something more could certainly be done even now to raise the standards of industry generally and thereby the standard of productivity. For such improvements, in the furthering of which the man of science will often have an essential part to play, help to persuade men and women that production is indeed a social task, and by raising what, for want of a better word, may be termed the morale of workers again, assist that greater interest and effort on which higher productivity depend. Here again is a field in which the scientific worker has much to contribute. The whole question of incentives offers vast scope for investigation by the psychologist, and other men of science may indeed be able to offer contributions. For success in this matter management must be bold and imaginative, and ready to experiment. Some of the essential scientific spirit must be given free play, linked to that respect for human personality which characterizes the 'clinical studies' described by Prof. Mayo; and this must pervade the trade unions as well as management. For this reason it is important that the man of science should be associated not only with the management of industry but also with the trade unions.

There is much that is suggestive in Prof. Mayo's work, and the ideas and methods he outlines do indeed point the way forward to a closer integration of industry with the society it exists to serve, and to a fuller understanding between worker and management. Furthermore, the discussion in the dispassionate spirit of science of the implications in full employment of the forty-hour or five-day week, staggered holidays with pay, pensions and retirement, and the relation of hours of work to age and physical fitness or disability, may assist us to reach new and imaginative solutions which will permit a wiser and more efficient use of man-power and woman-power at all ages, and the greater productivity which is now our imperative need. At the same time, such studies may lead to the release of men and women in industry from some of the excessive strain to which they are likely to be subjected when they first enter industry and, at a later stage, when their working life is drawing to its close.

SCIENTIFIC POLICY FOR THE NEW WORLD

Endless Horizons

By Dr. Vannevar Bush. Pp. ix + 182. (Washington, D.C.: Public Affairs Press, 1946.) 2.50 dollars.

THE concerted effort that linked the men of science of Great Britain during the Second World War was remarkable in the ease of its occurrence, in its achievements, and, contrary to many fears, in the fact that scientific 'planning' was not apparently associated with any evil consequences—except perhaps in so far as we did not plan sufficiently for the continuation of fundamental research. We were particularly fortunate in all this, and we owe a large part of our success to the fact that in the scientific and technical departments of the Service and other Ministries, and even more so in the Department of Scientific and Industrial Research, the Medical Research Council and Agricultural Research Council, we possessed powerful official agencies to act as a kernel for our scientific mobilization.

In this respect British men of science were far better off than their colleagues in the United States. Apart from certain Service establishments, the only counterpart to British official scientific organisation which was available to them when war broke out in Europe was the National Research Council, acting under the auspices of the National Academy of Sciences. The Council was a creation of the First World War; but either its structure was unsuited, or its practical influence on the scientific life of the United States during the inter-war years was insufficiently extensive, for the task of co-ordinating scientific activity on a national scale in an all-out war effort. In 1940 the President of the United States accordingly established a new committee, the National Defense Research Committee (N.D.R.C.), for the purpose of developing new weapons and instruments of war. A year later he founded an Office of Scientific Research and Development (O.S.R.D.), which absorbed the N.D.R.C., and had the function of co-ordinating the efforts of men of science and technical men in a much wider field of the war effort.

Dr. Vannevar Bush, previously head of the engineering section of the Massachusetts Institute of Technology, and at the time president of the Carnegie Institution of Washington, was placed in charge first of the one and then of the other of these two organisations. Their success so impressed Mr. Roosevelt that, towards the conclusion of hostilities, as is now well known, he called on Dr. Bush to submit a practical plan for the consolidation of the scientific gains of the War, both in the sense of making them as widely known as was consistent with military security, and of ensuring their continued extension by discovering, educating and endowing scientific talent in the United States. The O.S.R.D. was wound up not many months ago, and it is some months since open, official discussion of Dr. Bush's reply to the President languished in silence. In the interval two relevant changes have occurred. In the first place, scientific organisation in the United States has returned to its pre-war model, with the very important distinction that the Service Departments appear to have usurped the function of O.S.R.D. as the benefactors of large-scale research projects in the universities. In the second, the British have reacted to much the same type of consideration as exercised Dr. Bush when he was framing his reply to the President's question, by increasing the scale of university education, without making any inroads into university autonomy, and by trying to improve the organisation by which scientific advice makes itself felt in the national sphere at policy-making levels.

In the light of these two events, "Endless Horizons", which was published about a year ago in the United States, makes interesting reading—or re-reading—to-day. It is a collection of Dr. Bush's public utterances, between the years 1933–45, on technical and scientific matters. Its body is his report to the President, coupled with a brief account of the organisation and achievement of the O.S.R.D. Its frame is made up of such diverse, personal materials as his image of the 1930's as seen from a far-distant future when "all the desirable modifications of our natural environment" have been accomplished through some simple mechanical means; his well-known essay on the need for mechanical recording devices which will relieve the individual of much of the effort that still goes into the processes of natural memory and the exercise of formal logic; an essay on the conditions of scientific progress, called "The Teamwork of Technicians"; one on "The Qualities of a Profession"—dealing with the special case of engineers; another on the American tradition of opportunity; a lecture on "The Need for Patent Reforms"; and finally an address on "Science for World Service".

At the time of its appearance, Dr. Bush's report to the President was the subject of a leading article in these columns, and a large number of British men of science will be aware, at least in general, of the achievements of the O.S.R.D. The only new interest of the present volume is therefore a glimpse, even if an indirect one, of Dr. Bush's personal philosophy about the meaning of scientific activity. Coming as it does from the man responsible for the blue-print of America's future scientific organisation—even if at the moment the blue-print remains unrealized—it is an important one. The note is struck in his main report. "Without scientific progress," he told the President, "no amount of achievement in other directions can insure the health, prosperity and security" of the United States as a nation in the modern world; and since scientific progress is therefore of vital interest to Government, science must—in Dr. Bush's own words—be brought to the centre of the stage, and provided with a national policy which will ensure the rapid extension of a process, the utilization of science in the nation's welfare, which has only just begun. None of this message makes strange reading in Britain. What might be unexpected, however, is the predominantly material and social flavour of Dr. Bush's credo. It characterizes not only the reasons he gives for the federal action which he proposes, but those of his essays which are completely unrelated to this question. Dr. Bush, an apostle of science in the most individualist of countries to-day, calls for a national policy for science, and high-level planning for science, in far bolder terms and in a more materialist context than any but a few, if indeed anyone, has used in Britain.

His essays in "Endless Horizons" do not reveal much preoccupation with any abstract or non-applicable science. His 'historical' view of the 1930's, which opens the collection of essays, is a racy account of such inadequate gadgets as electric light, motor-cars, and spectacles. Nor does the implied picture

of the distant future in which science will have achieved all the desirable changes in these matters carry any suggestion that they will have been associated with any corresponding evolution in general understanding—beyond the implication which lies in the statement "science of the times [1930's] was disjointed, heterogeneous and very much an opportunist affair". The world, Dr. Bush explains to one of his audiences, "has arrived at an age of cheap complex devices of great reliability; and something is bound to come of it". To the President he wrote that "a nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill".

It is thus to a world of individualist enterprise that Dr. Bush makes his appeal for the establishment of a council to control the scientific policy of the United States. He may, of course, be wrong in assuming that advances in science when put to practical use necessarily "mean more jobs, higher wages, shorter hours . . . and higher standards of living"—since these things depend at least as much on socio-economic factors as on scientific progress. But whether the atmosphere be the rich and individualist one of the United States, or the Spartan and socialist one of Great Britain to-day, it seems to be generally recognized that the time has come for the State to play a central part in stimulating scientific progress.

It is equally to the interest of both countries that policy-making for science should not conflict with the peripheral autonomy of universities and research institutes in carrying out their research and educational programmes. Freedom of inquiry is a cherished possession; and, as Dr. Bush shows so clearly, because of the different and sometimes conflicting demands it must satisfy in different fields, national scientific policy is scarcely likely to lend itself to easy formulation. By itself science provides "no panacea for individual, social and economic ills". There is a possibility, to which Dr. Bush does not refer, that the widespread extension of scientific knowledge, and its methods, might achieve more in this respect than the direct exploitation of the material gains of science. Perhaps he deliberately avoided emphasizing this not-so-materialist point of view. History, however, will judge of the value of a national scientific policy by the wisdom of the compromise it effects between the more immediate satisfaction of domestic demands of security and economic and social welfare, and the longer-term necessity to spread the methods and fruits of scientific knowledge as widely and as internationally as possible.

S. ZUCKERMAN

THE LIQUID STATE

Kinetic Theory of Liquids

By J. Frenkel. (International Series of Monographs on Physics.) Pp. xi+488. (Oxford: Clarendon Press; London: Oxford University Press, 1946.) 40s. net.

THIS book does a great service by collecting together much scattered information on a fascinating and rapidly developing subject, contributions to which have appeared in a great many different journals. Discussion of liquids inevitably leads on to such topics as fusion and evaporation, the theory of solutions, the properties of polymers and rubber-like substances, and so on. Certain of these topics are dealt with at considerable length, others rather sketchily, and it is regrettable that no attempt has been made to link up the statistical theory of turbulence with the molecular theory of liquids. As is inevitable in so vast a subject, some of the matter is already out of date, and it is only right to mention that the book was written in Moscow in 1942, and has suffered delay in publication. In spite of these shortcomings, the book fills a very obvious gap, and cannot fail to be of permanent value to a serious student of any of these subjects. In spite of the War, the book is printed on very nice paper, and the high standard of craftsmanship that one instinctively associates with this series of monographs has been well maintained. The references are given in footnotes, which is far more convenient than grouping them at the end of the chapters, but one would welcome a complete bibliography at the end of the book, or else a subject index. Another improvement that could easily be made in a new edition is the addition of a list of symbols.

The reviewer feels bound to take exception to an objectionable feature of the book, which is the very scornful way in which the work of others is criticized. In a rapidly advancing subject it is inevitable that many theoretical deductions will be found to be based on erroneous premises, and a detailed criticism of such theories is of great value, and is, indeed, necessary for progress. In some instances, however, the author appears to think that a few words are enough to annihilate the rival theory, and, in at least one instance (p. 155 footnote), he does not attempt to explain his objections at all. Such an attitude is both unfair to the author of the theory and unhelpful to the reader who is trying to decide between two points of view. The reviewer quite agrees that many of these criticisms are justified, but there are cases where the author has been beguiled into definite errors by this over-hasty attitude. For example, p. 55: "As a matter of actual fact, such transitions have never been observed and cannot correspond to a stable equilibrium between the phases". (The type of transition referred to is a second-order transition as defined by Ehrenfest.) It is very hard to reconcile the first part of this sentence with the observed specific heat curves associated with the onset of superconductivity and with the transition of liquid helium. A definite refutation of the second part has been given by Bridgman[1].

The Lennard-Jones and Devonshire theory of melting is apparently criticized (p. 111) on the ground that the entropy-temperature curves (plotted at constant pressure) show a monotonic increase instead of being S-shaped. The answer to this is simply that the entropy-temperature curve consists of *two distinct* branches, corresponding to the two valleys in the surface depicting free energy as a function of volume and temperature. The process of melting at constant pressure consists of a transition from one branch to the other, and the melting temperature is determined by the usual condition that the Gibbs function must be the same for both phases.

Throughout most of the book, the author treats a liquid as having a structure akin to that of a solid the long-range order of which has been lost. Chapter 1 therefore starts by considering various possible processes by which 'holes' can appear in a crystal, and

lattice imperfections can diffuse through it. The length of this chapter seems excessive, as it seems to do little more than establish that the probability of such processes is governed by a factor of the type $e^{-W/kT}$, and to suggest various means of roughly estimating W. Chapter 2 contains a review of some of the theoretical work on order-disorder in alloys and the onset of free rotation in crystals. It is a pity that no mention has been made of the powerful 'quasichemical' method of Fowler and Guggenheim, which enables one to predict, at least approximately, the statistical consequences of very complex physical models which would be very difficult to treat by the older methods, and yet is easy to handle, and is, when applied to simple cases, precisely equivalent to the older theories. The advent of Onsager's work[2] will ultimately necessitate the revision of many of the conclusions of this chapter, particularly those related to the shape of the specific heat curves. It has become clear that the theoretical shape of the specific heat anomaly associated with a co-operative change will be very sensitive to the exact details of the model and to any approximations used in working it out.

Chapter 3 deals mainly with the process of fusion and various criteria for the stability of a crystal lattice, but it also contains an extremely able presentation and criticism of the work of Kirkwood and Prins on the 'structure function' of liquids, the assumptions and approximations that are made in this rather difficult but very important work being carefully pointed out. The discussion of the stability of a line of atoms under specified interatomic and external forces is also of great merit in exhibiting the relationships between the form of the interatomic interaction, the thermal expansion, and of the effect of heating or external forces on the stability of the lattice. An interesting result for the linear model is that it cannot be made stable against both longitudinal and transverse displacements, but this is no longer true for a three-dimensional model. The results are applied to give a rough theory of fusion, but no attempt is made to derive quantitative results.

Chapter 4 deals with the author's theory of viscosity of a liquid, which may be regarded as a generalization of the ordinary theory of elasticity of a solid, the response of a liquid to an external shear being specified by the rigidity modulus, together with a relaxation time specifying the mean life of a molecule in one equilibrium position. Analogous considerations are applied to the compressibility modulus and thus lead to the concept of 'volume viscosity', which is attributed to a relaxation time associated with structural changes in the liquid. From a consideration of the experimental data on absorption of supersonics in liquids it is concluded that the volume viscosity of liquids is large compared with the ordinary viscosity. The alternative explanation, analogous to the well-known theory of dispersion and absorption of sound in gases, is examined and rejected, as, to account for the observed absorption, it would require dispersion at frequencies of the order of 10^8 per sec., which is not observed. The reviewer agrees with this conclusion; but the value of this section would have been much enhanced by a critical summary of the experimental material. Another very interesting section in this chapter deals with the diffusion of gases and solids through liquids, and a reasonable explanation is given of the rather puzzling fact that the diffusion coefficients of different substances are of the same order of magnitude for a given liquid.

Chapter 5 is concerned mainly with the orientation of molecules in liquids, and the work of Debye, Onsager, Kirkwood and others on the problem of the behaviour of polar liquids in an electric field is expounded with great clarity; but here, again, very little experimental material is introduced, and the reader is consequently left in considerable doubt on how much the theories are claimed to explain.

Chapter 6 is mainly a phenomenological discussion of the properties of thin films of liquid and certain allied phenomena. Chapter 7 deals with the fascinating problem of the way in which phase-transitions actually occur. Two of the factors which cause actual transitions to depart from the ideal reversible transition are time-lag in the rearrangement of the molecules, which can lead to a liquid solidifying into the glass-like amorphous state instead of crystallizing, and surface tension. If the surface tension is positive, as it is between a liquid and its vapour, it is possible to superheat the liquid or supercool the vapour far beyond the equilibrium temperature before the transition takes place, because of the difficulty of forming a 'nucleus' of the more stable phase. If, however, the surface tension were negative, the formation of a nucleus would be facilitated, and metastable states would not be possible at all, even under ideal experimental conditions. In fact, no liquid with such a property is known, but it is possible to explain an apparent anomaly connected with fusion. The difference in surface-energies of solid and liquid is always small, but in some cases it is possible to supercool a liquid, and even to superheat a solid, provided that the latter is heated *internally*. Attempts to superheat a solid by heating its free surface invariably fail, however, and it seems that the effect of the free surface is always to lower the energy required to form a nucleus of the liquid phase, and this is what would be expected theoretically.

Chapter 8 deals with the theory of solutions, including those of high polymers, and the properties of rubber-like substances. The author's interests plainly lie in the two latter directions, and the treatment of 'classical' solutions is extremely sketchy, no attempt being made, for example, to expound or discuss the Debye–Hückel theory. The account of the present state of the theory of the behaviour of long-chain molecules seems rather incomplete; for example, no attempt is made to examine the error caused by treating a chain 50–100 'links' long as 'infinite'. Here, again, the lack of a survey of the experimental work on long-chain molecules is acutely felt.

In subjects of this sort, which are in their infancy, the comparison of theory with experiment leads to less clear-cut conclusions than it does in more developed fields of physics. Any theory will, in this field, certainly involve several adjustable constants, and it may well be possible to fit even a wrong theory to most of the facts; but all facts that *cannot* be fitted should certainly be recorded. The fact that this has often not been done detracts somewhat from the merits of a very readable presentation of some far from simple theoretical work. The author never once seems to be carried away by the mathematics, but keeps the essential physical ideas before his reader throughout.

H. N. V. TEMPERLEY

[1] *Phys. Rev.*, **70**, 425 (1946).
[2] *Phys. Rev.*, **65**, 117 (1944).

THE BODY'S CHEMICAL MECHANISMS OF DEFENCE*

By Dr. C. R. HARINGTON, F.R.S.

THE defence of the body against the poisonous action of compounds of simple chemical constitution is effected by a variety of chemical reactions. The toxic compound may be oxidized to a non-poisonous product, or to one for which a rapid means of elimination exists. Non-oxidative processes of elimination usually involve conjugation with a normal constituent of the body to give a substance which is relatively non-toxic and is readily excreted. The body shows considerable versatility in the means which it adopts for conjugation of toxic compounds. Examples are the formation of ethereal sulphates from phenols, of glucuronides from phenols and aromatic acids, the combination of organic acids with amino-acids to form products of the hippuric acid type, and the detoxication of halogenated benzenes by linking with acetylcysteine to form mercapturic acids. A certain species-specificity is shown in detoxication by conjugation with amino-acids; thus benzoic acid is combined with glycine to give hippuric acid in all mammalian species so far examined, but in birds it is coupled with ornithine to give ornithuric acid; similarly, phenylacetic acid is detoxicated by conjugation with glycine in man and the chimpanzee, with ornithine in birds and with glutamine in the dog, rabbit, cat and monkey.

The reactions by which detoxications take place occur for the most part in the liver, and their quantitative examination can therefore be made the basis of assessment of hepatic efficiency. This is illustrated by the use of the measurement of hippuric acid excretion following a standard dose of benzoic acid as a liver function test.

Chronic poisoning with a compound which is detoxicated by conjugation may lead to deleterious effects even though the actual conjugating mechanism remains unimpaired. This may happen when the substance utilized by the body for the detoxicating reaction is one which is an essential constituent of the tissues and is at the same time limited in supply. In the case of the mercapturic acid conjugation, the constituent supplied by the body is acetylcysteine, which is a derivative of the essential amino-acid cystine. Since the amount of cystine in the diet is limited, prolonged administration of a compound such as bromobenzene to a growing animal may show its effects by limiting growth, owing to the drain imposed on the supplies of available cystine, in the absence of any signs of direct poisoning by the bromobenzene itself.

Apart from the species-specific utilization of different amino-acids for the detoxication of organic acids, the processes by which the body deals with simple chemical poisons are for the most part group reactions; so that it is possible, from a knowledge of the chemical constitution of a poisonous substance, to predict the probable route of its detoxication.

In protecting itself against invasion by pathogenic bacteria or against the effects of toxins produced by such bacteria, the body adopts entirely different methods.

An attack of an infectious disease frequently produces a condition of life-long immunity to the same illness; immunity of long duration can also be achieved in many cases by vaccination with the killed causative organism, or with products obtained from this organism. In addition to the active state of immunity thus conferred by natural infection or by vaccination, a temporary passive state of immunity can be produced by treatment with the blood serum of an animal which has been infected with the disease or has been vaccinated against it. These facts indicate that the process of immunization calls forth a response in the body which confers upon it powers of defence against subsequent invasions by the same organism; and the phenomenon of passive immunization suggests strongly that these powers are associated with a definite change in the blood of the immune individual.

The fact that the blood is actually altered as the result of immunization can be demonstrated by various reactions in the test-tube. Thus a suspension of infective bacteria, which remains quite stable when mixed with normal blood serum, may be agglutinated when mixed with the serum of an individual immune to the disease caused by the particular bacterium concerned. When the bacterium produces a soluble toxic substance, this will be precipitated and neutralized by the immune serum but not by normal serum. In other instances the bacterium may actually be dissolved by the immune serum. It thus becomes possible to envisage the defence reaction of the body against infection in terms of physical or chemical interaction between a substance newly formed in the blood, which may be designated 'antibody', and the eliciting agent (bacterium or bacterial product), conveniently called 'antigen'.

Although the presence of antibodies in the blood can be demonstrated by a variety of test-tube reactions, there is no real reason to suppose that they are of correspondingly different types. The general features of the antigen-antibody reaction are those of an ordinary colloid chemical reaction (including the zoning phenomenon), and it is more probable that the different physical manifestations of the reaction reflect differences in the physical state of the antigens. All available evidence supports the view that antibodies are specifically altered forms of a definite fraction of the serum globulins.

Antigenic power is not confined to pathogenic bacteria and their products, but extends generally to all proteins which are foreign to the body. Such foreign protein does not act antigenically when taken in the food, because it is broken down by digestion; if, however, it is introduced directly into the deeper tissues of the body it elicits a response similar to that produced by bacteria. There is a considerable variation in the antigenic power of different proteins, the highest activity being found among the proteins of the blood and actively metabolizing tissues, and the least among the highly specialized hormonal proteins.

The power of foreign proteins to act as antigens has been used extensively for the study of the specificity of the antigen-antibody reaction. The method adopted has been to induce known alterations in the protein molecule by the use of reagents which attack the functional groups of the latter. Examples are the use of acid chlorides and azides which react with amino- and hydroxyl-groups, treatment with halogens which enter the benzene ring of tyrosine, and coupling with diazonium salts which again react with tyrosine; the latter method particularly has made it possible to introduce a large variety of new groups into

* Abstract of the Friday Evening Discourse at the Royal Institution on December 13.

proteins. Study of artificial protein derivatives produced in this way has shown that a new antigenic specificity is conferred by the group introduced, which frequently masks the original specificity almost completely. For example, if an iodinated protein is used as antigen, the antiserum against it will fail to react with the original protein but will react with iodinated proteins in general. A very high degree of specificity is attached to the new group introduced, minor chemical differences such as that between α- and β-glucosides being detectable in the antigen-antibody reaction *in vitro*. If the new group has physiological activity, this may be neutralized by the antiserum in the same way as a toxin is neutralized by an antitoxin.

The precipitation of an artificially altered protein by its specific antiserum is inhibited if the antiserum is first treated with excess of the simple chemical compound attached to the protein in the preparation of the antigen. The inhibition occurs because the specific combining sites on the antibody are occupied by the simple compound, and antigen-antibody combination is thus prevented. This inhibition reaction therefore gives reality to the conception that the new groups introduced into artificial protein antigens form actual points of attachment with the antibody, and justifies the designation of such groups as 'haptenes'.

It is now known that among bacteria a situation exists which is similar to that described for the artificially conjugated antigens. Bacteria in general contain complex polysaccharide groups, and it is these groups which confer antigenic specificity; they are in fact bacterial haptenes, and it is they which determine the structure of the specific antibodies formed against bacteria.

The defence mechanism of the body against bacterial invasion thus consists in the development of antibodies, by virtue of the antigenic power of bacteria due to their content of foreign protein; the nature of the antibodies is determined by the structure of the bacterial antigen, and in particular by the carbohydrate group of the latter, so that they acquire the specific power of entering into colloidal combination with antigen which they may eventually encounter. The results of the combination, as seen in the test-tube, may be manifold; but with whatever *in vitro* reaction they are associated, their object, so far as the body is concerned, is protection against the harmful effects of the bacterium or of its products.

The very readiness of the body to react to the introduction of foreign protein, which is essential in the development of defence against bacterial invasion, can itself be an embarrassment. The ordinary defence mechanism which has been described is developed naturally against a continuously increasing amount of antigen, as when invading bacteria undergo multiplication or produce increasing amounts of toxin. Similarly, in artificial immunization, the antigen is usually applied in frequent and increasing doses. If a single small dose of antigenic material is injected into an animal and the latter is left for ten or more days, it passes into a hypersensitive state in which acute toxic effects are produced by a second small dose of the same antigen. The phenomenon is seen in its extreme form in the guinea pig, in which the second dose results in acute bronchial spasm, frequently leading to death of the animal. Accidental sensitization often occurs in human beings, who are, however, much less reactive than the guinea pig; the analogue of the fatal bronchial spasm (anaphylactic shock) in the latter is the attack of asthma in the individual who has become sensitive to a protein such as that of the dandruff of horse-hair whenever he is exposed to the original sensitizing agent. In general, phenomena of this type are described as allergic, to indicate the altered reaction by which the body responds to contact with a previously harmless substance as if it were a powerful poison; in addition to asthma, they include the catarrh of hay fever, the nettle rash associated with sensitivity to certain foods, and the dermatitis which results from superficial contact with sensitizing agents and which is perhaps the commonest manifestation of allergy in man.

The nature of many of the substances which induce allergy and the specificity with which they exercise their effects indicate that the allergic phenomenon is essentially an antigen–antibody reaction. On the other hand, it is usually impossible to detect antibodies to the sensitizing agent in the blood of an allergic patient, so that the antibodies must be fixed to certain tissues (such as the bronchial musculature or the skin) which respond by abnormal reaction to contact with antigen.

Allergic phenomena, and particularly dermatitis, are frequently produced by simple chemical compounds unrelated to protein. The explanation of this is that such compounds are either themselves able to react with proteins or are converted in the body into a reactive form. They may thus be designated pro-antigens, since although they are themselves not antigenic they will, when they gain access to the body, react with tissue proteins and so alter these as to turn them into antigens. Pro-antigenic compounds of this type are met with not infrequently; examples are *p*-phenylenediamine, which is responsible for dermatitis from furs, and the sensitizing principles of *Primula* species and poison ivy (*Rhus Toxicodendron*) which make it impossible for some individuals to touch these plants without acute skin irritation. They occur still more commonly in chemical industry, where they may be a source of serious inconvenience.

In general, allergy may be regarded as being at the same time an illustration of the defensive reactivity of the body against foreign protein and a deviation of the defence mechanism which is actually deleterious.

COUMARIN AS A SELECTIVE PHYTOCIDAL AGENT

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THE recent discovery[1,2] that synthetic plant-growth substances such as 2 : 4-dichlorophenoxyacetic acid have selective phytocidal actions in very low concentrations has opened up a new field of investigation into their mechanisms of action. The search for new molecules with similar properties has been intensified. The fact that unsaturated lactone groupings are frequent features of naturally occurring substances having inhibitive effects on cell-growth[3,4,5] revives interest in the phytocidal activity of the common plant metabolite, coumarin. This substance was, apparently, first shown by Klebs[6] to be toxic to Algæ, and later by Schreiner, Reed and Skinner[7] to

have inhibitive effects on the growth of wheat. Cameron[9], in a discussion on soil fertility, referred to the fact that both coumarin and daphnetin prevented the development of wheat, and Sigmund[9] noted the effects of daphnetin and æsculetin on seed germination. In 1934, Köckemann[10] gave the term 'blastocholine' to material of unknown structure, present in ripe fruits, which suppressed germination of cress seeds. Since then it has been shown[11,12,13] that a number of unsaturated lactones, including coumarin, parasorbic acid and β-angelicalactone have blastocholine effects, suppressing germination of seeds at concentrations such as 100 parts per million. The concentrations at which the lactones are effective have been considered to be much higher than those which bring about comparable effects with 2 : 4-dichlorophenoxyacetic acid.

Selective Phytocidal Action of Coumarin

In view of these facts, we decided to set up experiments, with a number of plant species, to investigate the possible activity of coumarin as a selective phytocidal agent. Comparisons were made of the effects of coumarin with those of 2 : 4-dichlorophenoxyacetic acid on the same species of plant. A water culture technique was employed. 15 ml. portions of standard water culture solution (the same as that of Nutman, Thornton and Quastel[1] was used, with the omission of potassium nitrate) containing various dilutions of the phytocidal agent were placed in ¾-in. test-tubes, and 'thimbles' of glass wool were then pushed down the tubes until they just touched the surface of the medium and became soaked by it by capillary action. These 'thimbles' stayed firmly in place in the tubes during all subsequent handling, and were found to be very efficient supports for the seeds. They ensured optimum aeration and constant contact with the medium, and in addition, the radicles could easily grow through the fine sieve-like meshes into the culture medium itself. The tubes were plugged and then autoclaved, and all seeds were surface-sterilized with 80 per cent alcohol and dilute mercuric chloride[1] before sowing in the tubes. Samples varied in number from 30 to 100 seeds per tube, depending on the species under consideration. The need for thorough sterilization of culture media and surface sterilization of the seeds had been made obvious to us in preliminary experiments with indolylacetic acid. This substance, which shows high phytocidal activity in sterile media[1] at a concentration of one part in ten million, loses its activity in unsterilized media, owing to vigorous bacterial attack. Precautions concerning sterility were therefore taken in testing the phytocidal activities of all plant-growth substances used in small concentrations.

Seeds were allowed to germinate for 1–2 days in the dark and then grown in normal daylight at 20° C. When the roots of the 'control' seedlings had reached a suitable length (generally after about 7–10 days growth) the experiment was stopped. The roots of all sets of seedlings of a series were cut off with a sharp scalpel, dried rapidly on blotting paper, and were then weighed rapidly and accurately to the nearest 0·1 mgm. This final weight of root has been taken as the measure of growth for estimation of the phytocidal action of the substances concerned. It has been shown, for 2 : 4-dichlorophenoxyacetic acid and other similar agents, that root-growth is the most sensitive and consistent measure of their effects. In addition, the percentage germination was also determined in each case.

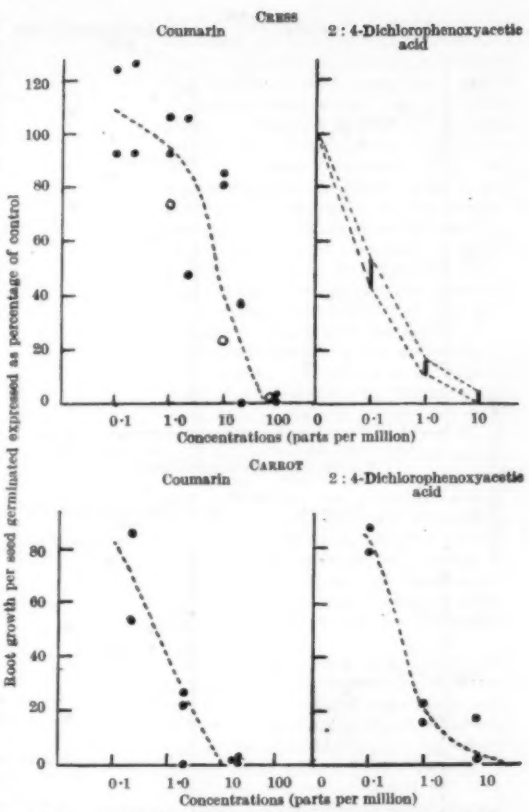


Fig. 1. Effects of solutions of various concentrations of coumarin and 2 : 4-dichlorophenoxyacetic acid on the root-growth of seedlings of cress and carrot

Figs. 1 and 2 show typical results for two of the species investigated, cress and carrot. In order to separate so far as possible the two physiological effects, namely, on germination and on the subsequent root-growth, root weights have been calculated as a sample average per seed germinated. In Fig. 1 these values are expressed as percentages of those in the control tubes in each case. A large amount of data has been accumulated (approximately twenty experiments) on the effects of 2 : 4-dichlorophenoxyacetic acid on root growth of cress, and in the relevant graph the growths are plotted as vertical lines about the mean value. These lines have a range equal to the standard error on either side of the mean.

From the two sets of graphs the following main points stand out :

(1) Coumarin exerts a dual effect, namely, a marked inhibition of both germination and root-growth subsequent to germination. Root-growth is slightly more susceptible than germination. In contrast to this, 2 : 4-dichlorophenoxyacetic acid shows no significant effect on germination over the range of concentrations used, although root-growth is reduced to very low values in the highest concentrations of 10 parts per million.

(2) The action of coumarin is a differential one, carrot being about twenty times as sensitive as cress, whereas these two plants appear to be equally sensitive to 2 : 4-dichlorophenoxyacetic acid.

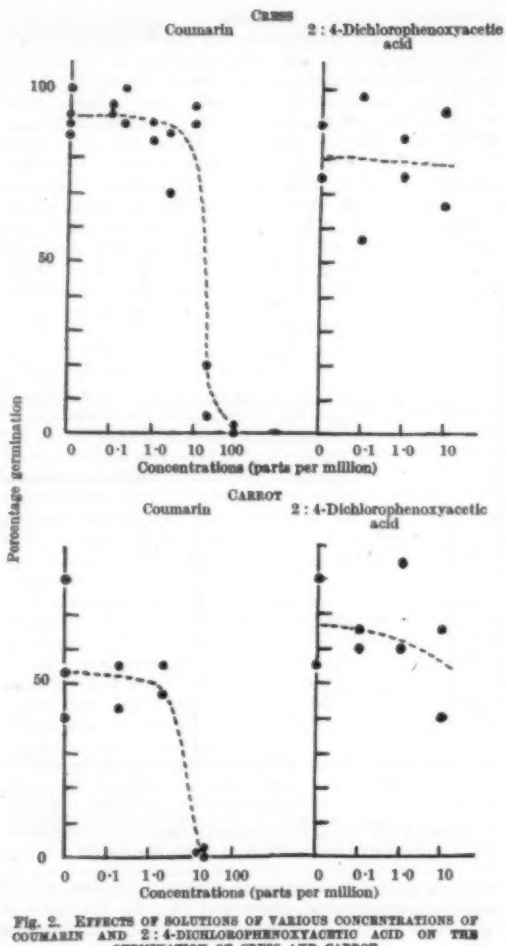


Fig. 2. Effects of solutions of various concentrations of coumarin and 2 : 4-dichlorophenoxyacetic acid on the germination of cress and carrot

In all, nine widely different species of plant have been tested. From graphs similar to those of Figs. 1 and 2, the accompanying table has been drawn up showing the concentrations in parts per million of coumarin and 2 : 4-dichlorophenoxyacetic acid necessary to reduce the root-growth and the germination to 50 per cent of the control values in each species.

Species	50% inhibition of root growth		50% inhibition of germination	
	Coumarin (p.p.m.)	2 : 4-Dichlorophenoxyacetic acid (p.p.m.)	Coumarin (p.p.m.)	2 : 4-Dichlorophenoxyacetic acid (p.p.m.)
Cress	11	0·2	11	Greater than 10 in all cases
Radish	8	0·6	10	
Mustard	8	0·15	>20	
Carrot	0·5	0·3	5	
Onion	15	0·3	>20	
Mixed lawn grass	4	>10	4	
Beetroot	12	0·11	>20	
Taraxacum officinale	10	6·0	6	
Cabbage	50	0·04	4	

From this table it will be seen that coumarin exerts the same order of differential action as 2 : 4-dichlorophenoxyacetic acid itself, although on the average, so far as root-growth is concerned, it is between a tenth and a hundredth as effective. In addition, the differential action does not run parallel; for example, whereas cabbage and cress are most sensitive to 2 : 4-dichlorophenoxyacetic acid, they are least sensitive to coumarin. Grass, on the other hand, is more sensitive to coumarin than to the other compound. Carrot is equally sensitive to both.

Formative Effects

Experiments on a number of dicotyledonous species have shown that continued growth of certain species in concentrations of 2 : 4-dichlorophenoxyacetic acid of the order of 1–10 parts per million gave rise to characteristic formative effects on the base of the hypocotyl. This is shown very markedly in radish and to a lesser extent in cress and carrot, where the lower half of the hypocotyl swells to two or three times its normal diameter and becomes translucent in appearance. The histological changes concerned in this are now under investigation. It is interesting to note that coumarin, in concentrations giving the same degree of inhibition of root-growth, also gives similar formative effects on the hypocotyl.

Action of Coumarin in Soil

In addition to experiments in sterile water culture, others have been set up in soil. Small glass pots with a basal vent were filled with air-dry garden soil and then saturated with coumarin solutions of various concentrations (1, 10 and 100 p.p.m.) and allowed to drain. Seeds of the above-mentioned species were then sown in a series of concentrations as in the water-culture experiments, and allowed to germinate. Subsequent watering of the soil was with distilled water, care being taken not to wash out the coumarin with excess water.

Germination and growth gave the same general picture of the effect of coumarin as in the test-tube experiments, but there seemed to be a general all-round reduction in its effectiveness. In addition, seeds, the germination of which had been inhibited in the high concentrations of coumarin, eventually germinated after a lag period of about five days. Subsequent growth was as in the control. It seemed therefore that coumarin, like heteroauxin (β-indolylacetic acid), may be destroyed in soil, and that its inhibition of germination is reversible.

Coumarin Breakdown in Soil

Experiments have been carried out with the assistance of Mr. P. G. Scholefield of this Unit on the breakdown of coumarin in soil, and these will be reported upon in detail in due course. The procedure and results are, briefly, as follows:

A saturated solution of coumarin (100 p.p.m.) was circulated through soil in a soil perfusion apparatus[10] and its rate of disappearance from soil was investigated using a sensitive colorimetric method for the estimation of coumarin. It was found that, following an immediate adsorption of part of the coumarin on the soil, a microbiological attack takes place, and the coumarin disappears completely from the soil, under the given experimental conditions, within forty-eight hours. Certain bacterial poisons inhibit the breakdown of coumarin in soil, and investigations are now being carried out to see if the addition of

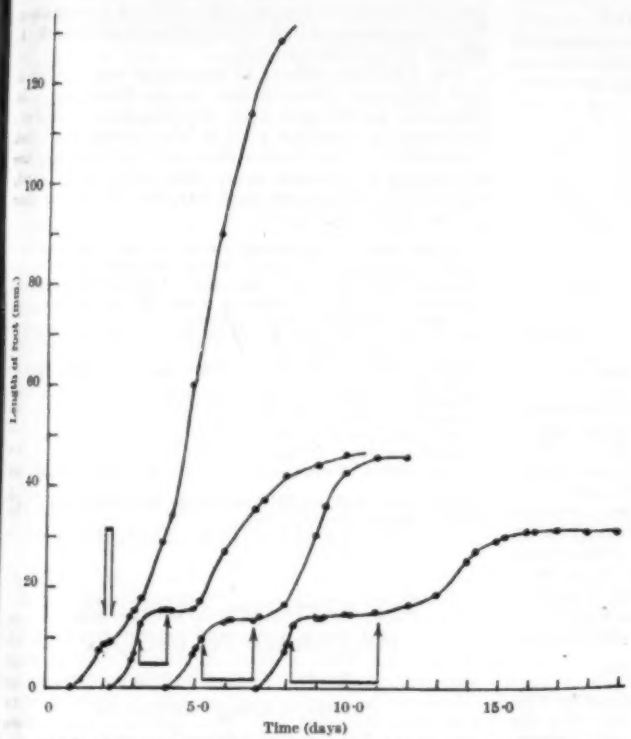


Fig. 3. CURVES SHOWING THE REVERSIBILITY OF THE ACTION OF COUMARIN ON THE GROWTH OF ROOTS OF CRESS. THE POINTS OF ORIGIN OF THE INDIVIDUAL CURVES (THAT IS, TIMES OF COMMENCEMENT OF THE EXPERIMENTS) ARE SPREAD OUT ALONG THE TIME AXIS TO AVOID CONFUSION

such poisons to soil will render coumarin more effective as a phytocidal agent under soil or field conditions.

Reversibility of Action by Coumarin

It is clear that for any understanding of the mode of action of such phytocidal agents as 2 : 4-dichlorophenoxyacetic acid and coumarin, it is essential to know if their inhibitive effects are reversible. If these compounds have toxic effects because they combine in an irreversible manner with cell constituents, their effects will be irreversible, and washing the plant tissue to remove the toxic agent will not result in renewed growth of the plant. On the other hand, if these agents act by forming easily dissociated compounds with tissue constituents, whether they are enzymes or metabolites, washing the plant tissue to remove the toxic agent should result in renewed growth of the plant, so long as autolytic processes have not advanced too far during the interval of time in which growth has not taken place.

We have carried out experiments on the reversibility of action of 2 : 4-dichlorophenoxyacetic acid and of coumarin, and it is clear that, with both substances, reversibility does take place. We propose to give the results of experiments with coumarin, while the details of the work with the other substance will be reported upon later.

Two types of experiment were carried out :

(1) *Reversibility of inhibition of germination.* Cress seeds were soaked in saturated coumarin solution and stood aside in the dark. At intervals of twenty-four hours, the seeds were removed and supported on the surface of a constant, slow-running stream of water-culture solution. Control seeds germinated twenty-four hours after soaking at 20° C. Seeds removed from the coumarin solution after 1, 2, 3 and 4 days, and then washed, all germinated about 36–48 hours after washing, with subsequent normal growth. Longer exposure to coumarin solution of this concentration resulted in complete destruction of the germinative capacity of the seeds.

(2) *Reversibility of the inhibition of root-growth.* In addition to experiments on germination, observations were made on the reversibility of coumarin action on the growth of cress roots. In these experiments, individual seeds were germinated and grown in an aerated water-culture solution which was constantly circulated over them, and the growth of roots was followed by means of a travelling microscope reading to 0·02 mm. Full details of the apparatus and methods will be published in a later paper.

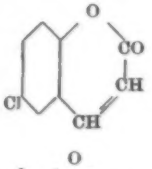
It was found that the addition of coumarin to the circulating solution has the same effects on the growth of individual roots as those observed by the test-tube technique. The open circles in the first graph of Fig. 1 show the values obtained by this method. Experiments were carried out by exposing the root to a circulating culture medium containing 100 p.p.m. of coumarin for varying periods of time and then replacing with pure culture solution. The graph of Fig. 3 shows typical effects of this procedure on the growth of roots of cress. The pairs of vertical arrows mark the duration of the exposure to coumarin in each case (in this experiment 6, 22, 40 and 68 hours). It will be seen that 100 p.p.m. of coumarin gradually reduced the growth-rate to zero during a period of 12–18 hours, and that replacing in fresh circulating culture medium brings about partial recovery. The degree of this partial recovery seems directly correlated with the time of exposure to the coumarin.

Insufficient experiments have been carried out, so far, to do more than make it clear that when a seedling has ceased to grow in coumarin solution for periods up to two or even three days, recovery can take place. It is scarcely to be expected that the recovery will be more than partial; first, because it is unlikely that washing, however good, will remove all the toxic agent, and secondly, because, during the period in which growth is not occurring, autolytic processes must be taking place to the detriment of the subsequent growth. Studies of the chemical events occurring in the plant during the period of inhibited growth should help to throw light on the chemical mechanisms underlying the action of the phytocidal agents. Further experiments have shown that recoveries from the inhibitive effects of coumarin or 2 : 4-dichlorophenoxyacetic acid may be more complete in certain plant species than in others.

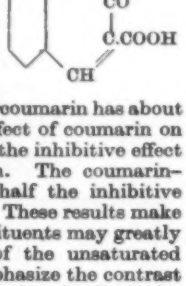
Effects of Coumarin Derivatives

Two derivations of coumarin have been synthesized by Mr. P. G. Scholefield and have been tested to see if they have phytocidal activities. They are:

(i) Monochlorcoumarin



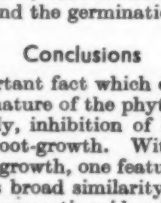
(ii) Coumarin-carboxylic acid



Tested on the carrot, monochlorcoumarin has about one twenty-fifth the inhibitive effect of coumarin on the growth-rate, and one quarter the inhibitive effect of coumarin on the germination. The coumarin-carboxylic acid has about one half the inhibitive activities of monochlorcoumarin. These results make it clear that the presence of substituents may greatly affect the phytocidal activity of the unsaturated lactone ring. Moreover, they emphasize the contrast between coumarin and phenoxyacetic acid, for in the latter the introduction of a chlorine atom into the benzene ring results in increased phytocidal action.

Protoanemonin and Ranunculin

We have been able to carry out experiments with ranunculin (kindly supplied to us by Dr. R. Hill), the diglucoside of protoanemonin, and with protoanemonin itself



as possible phytocidal agents.

Preliminary experiments have shown that protoanemonin is much more effective, and ranunculin is slightly less effective, than coumarin in suppressing the root-growth and the germination of cress.

Conclusions

The most important fact which emerges from this work is the dual nature of the phytocidal activity of coumarin; namely, inhibition of both germination and subsequent root-growth. With respect to the inhibition of root-growth, one feature of the activity of coumarin is its broad similarity to the action of 2 : 4-dichlorophenoxyacetic acid and other phytocidal agents of the heteroauxin class. Although it is only active in this respect at relatively high concentrations (of the order of 10 parts per million), its differential effects are just as clearly defined as, and its formative effects are apparently identical with, those of 2 : 4-dichlorophenoxyacetic acid. Moreover, in the case of at least one plant, carrot, the inhibitive effects of coumarin at a concentration of one part in two millions are as great as those of 2 : 4-dichlorophenoxyacetic acid.

With respect, however, to the inhibitive effects on germination, coumarin is much more active with certain plants than 2 : 4-dichlorophenoxyacetic acid, which in the highest concentrations used (10 parts per million) has no suppressing effects on germination. The two substances also differ in that their differential effects do not run parallel.

The inhibitive effects of coumarin are reversible, and extensive observations (to be reported) with cress and garden pea show that the action of 2 : 4-dichlorophenoxyacetic acid is also reversible. The facts indicate that these substances must effect their inhibitions by forming loose combinations, or easily dissociated compounds, with enzymes or metabolites in the plant cell.

[1] Nutman, Thornton and Quastel, *Nature*, **155**, 498 (1945).
[2] Slade, Templeman and Sexton, *Nature*, **155**, 497 (1945).
[3] Langer, Martin and Muller, *Helv. Chim. Acta*, **27**, 892 (1944).
[4] Medawar, Robinson and Robinson, *Nature*, **151**, 195 (1943).
[5] Veldstra, *Enzymologia*, **11**, 373 (1944).
[6] Klebs, "Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen" (Jena, 1896).
[7] Shreiner, Reed and Skinner, U.S. Dept. Agric. Bur. Soils, Bull. 47 (1907).
[8] Cameron, *J. Phys. Chem.*, **14**, 422 (1910).
[9] Sigmund, *Biochem. Z.*, **62**, 339 (1914).
[10] Köckemann, *Ber. Deut. Bot. Ges.*, **52**, 523 (1934).
[11] Haynes and Jones, *J. Chem. Soc.*, 954 (1946).
[12] Kuhn, Jerchel, Moewus, Müller and Lettré, *Naturwiss.*, **31**, 46 (1943).
[13] Veldstra and Havinga, *Rec. Trav. Chim.*, **62**, 841 (1943).
[14] Audus, *Nature*, **158**, 419 (1946).

AN ARMAGH–DUNSINK–HARVARD TELESCOPE

By Dr. E. M. LINDSAY
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PLANS for the setting up of a Baker–Schmidt telescope on the site of the Boyden Station of the Harvard Observatory, Bloemfontein, South Africa, are now complete. It will be the first instrument of its kind in the world, and will also be a noteworthy example of inter-country international co-operation. The instrument will be operated jointly by the Armagh Observatory, Northern Ireland; the Dunsink Observatory, Dublin, Eire; and the Harvard Observatory, Cambridge, U.S.A. It will be known as the Armagh–Dunsink–Harvard Telescope. The Governments of Northern Ireland and of Eire have each promised to contribute £5,000 towards the cost of the new instrument, and Harvard Observatory will provide the rest of the funds. Harvard will also provide appropriate caretaking and maintenance service, the necessary power and light for the proper operation of the instrument, and access to library and dark-rooms for all observers. The observing time with the instrument will, however, be shared equally by all three Observatories.

The main mirror of the new telescope will be of 36-in. aperture, the secondary mirror of not less than 16-in. and the correcting plate of not less than 30-in. diameter. The famous 24-in. Bruce refractor of the Harvard Observatory will be dismantled, and its mounting and drive will be used for the Baker-Schmidt. It is expected that the new reflector will be about three times as fast as the Bruce. The present 24-in. prism of the Bruce will be re-figured, or a new objective prism manufactured.

Four months of observing in South Africa should provide for each observer approximately three years of research. Thus an observer need spend only about ten per cent of his time away from his own Observa-

tory. The new telescope will require an increase of staff at the Armagh Observatory. To provide for this, the Government of Northern Ireland has promised to give an increased annual grant to the Observatory. The Government of Eire has taken over Dunsink Observatory, which will be re-opened and will be incorporated in a new school of cosmic physics attached to the Dublin Institute of Advanced Studies.

The new Armagh–Dunsink–Harvard telescope will help to fill the long-felt need for more observational material from the southern hemisphere. It will be ideally suitable for such varied problems as galactic structure, variable stars, spectrophotometry, standard photometry, galactic nebulæ, external galaxies and, possibly, statistical radial velocities.

Harvard will be responsible for the design of the reflector, and the Perkin–Elmer Corporation, Glenbrook, Connecticut, has already started on its manufacture. It is hoped that the instrument will be in operation within eighteen months.

INTERNATIONAL COMMITTEE OF WEIGHTS AND MEASURES

AFTER an interval of nine years, the International Committee of Weights and Measures held its first plenary session since 1937 during October 22–29, 1946. The meetings of the Committee which should have taken place in 1939 could not be held owing to the outbreak of war, and the only other meeting which has been possible in the meanwhile was an unofficial one of a few members in 1945 to prepare the way for the recent session. By its constitution, the members of the Committee, which functions under the authority of the treaty known as the "Convention du Mètre", must all be of different nationalities. On this occasion the members present were MM. Louis de Broglie (France), G. Cassinis (Italy), M. Chatelain (U.S.S.R.), E. C. Crittenden (U.S.A.), M. Dehalu (Belgium), W. J. de Haas (Holland), E. S. Johansen (Denmark), W. Kösters (Germany), Z. Rauszer (Poland), M. Ros (Switzerland) and J. E. Sears (Great Britain), together with M. A. Pérard, director of the Bureau International des Poids et Mesures.

The Committee had first to record, with deep regret, the deaths, since its last meeting in 1937, of six former members: MM. B. Cabrera (Spain), Ch. Fabry (France), D. Isaachsen (Norway), A. E. Kennelly (U.S.A.), V. Volterra (Italy) and P. Zeeman (Holland). In the passing of six such distinguished men of science from its numbers, including both its president, M. Volterra, and secretary, M. Cabrera, the Committee has suffered a very severe loss. No news has been received of Prof. Nagaoka, the Japanese member, since 1939, and it is not at present known if he is still alive.

Mr. J. E. Sears was elected president for the current session, and M. Dehalu was elected secretary. M. Pérard presented, and briefly outlined the main features of, his report on the activities of the Bureau International for the period September 1, 1939–August 31, 1946. This was referred for more detailed study to two sub-committees, the Commissions des Travaux, and des Finances, respectively.

The Committee reviewed and confirmed the decisions taken provisionally by the unofficial meeting in 1945. A letter was then read from the French Government asking that, for the future, the Conservatoire des Arts et Métiers should be regarded as the French National Metrological Laboratory, eligible to nominate technical experts, on the invitation of the International Committee, to serve on its Advisory Committees for Electricity, Photometry and Thermometry. This was agreed to.

At their second meeting the members of the Committee made the usual formal visit of inspection to the vault at the Bureau, where the International Prototype Metre and the International Prototype Kilogramme are preserved. They were able to see the reinforcement which had been built into the vault to protect it from the possible shock of bombardment, and noted with satisfaction that, although several bombs actually fell in the grounds of the Bureau, no damage whatever occurred to any of the invaluable standards contained in the vault.

The Committee then proceeded to the consideration of the Report of the Commission des Travaux on the work of the Bureau during the past seven years. It is satisfactory to be able to record that, in spite of difficulties arising from war conditions, the Bureau has been able to make good progress with its programme. In particular, new sections for the comparisons of electric and photometric standards have been installed to deal with the additional duties entrusted to the Bureau following the revision of the Convention du Mètre in 1921.

The Report contains an interesting account of the re-comparison—the first since its original adoption in 1889—of the International Kilogramme with its *témoins*—the working standards of the Bureau. The results obtained agreed with those found in 1889 within 0·05 mgm. in every case, and within 0·01 mgm. in the mean. This, however, was only attained after special cleaning of the weights, first with chamois leather, moistened with benzine, and then with a jet of steam. Prior to this treatment the maximum change recorded was 0·083 mgm., with an apparent increase in the mean value of the *témoins*, relative to the International Kilogramme, of 0·045 mgm.

Improvement has been effected in the accuracy of comparison of the metre standards (*a*) by re-engraving some of those (other than the International Metre itself) which had defining lines inferior to the best attainable by modern means, and (*b*) by the introduction of microscopes on the comparator adapted to rotate about their axes so that the effects of any asymmetry in illumination can be eliminated. It is claimed that as a result of these measures the accuracy of comparison of two metre standards is now within ±0·1 micron. The working standards of the Bureau, which were dispersed for safety during the War, have been re-compared, with results agreeing within this figure with their former values. The possibility of adopting a unit of length defined in terms of a wave-length of light was discussed, but further experimental work is considered necessary before final effect could be given to this proposal.

A proposal that the Bureau should undertake a new determination of the value of gravity, by direct cinematic observation of a freely falling body, was approved by the Committee. A further suggestion, to undertake a new determination of the velocity of light, was negatived on the ground that it was considered to be outside the terms of reference of the Bureau.

The Report of the Commission des Finances showed that the accounts of the Bureau had been properly

kept. A number of States, particularly those which have been in enemy occupation during the War, are in arrears with their subscriptions, and the Committee discussed the steps necessary to regularize the position. The present arbitrary rate of exchange of the French franc has been a cause of difficulty to the Bureau, and a recommendation to ask the next Conférence Générale for an increased rate of subscription was accepted by the Committee.

The Committee then proceeded to a consideration of the membership of the three advisory committees. In addition to the Conservatoire des Arts et Métiers, to which reference has been made above, the national laboratories invited by the International Committee to appoint representatives on these committees are: the Bureau of Standards, Washington; the Institut de Metrologie, Leningrad; the Laboratoire Electrotechnique, Tokyo; the National Physical Laboratory, Teddington; and the Physikalisch-Technische Reichsanstalt, Charlottenburg. Further, three independent specialists in the respective subjects, together with the presidents of these committees, are directly nominated by the International Committee. M. Chatelain having declined the office on the ground that he lived too far away from Paris, Mr. Sears was elected president of the Advisory Committee for Electricity. Mr. Crittenden was elected president of the Advisory Committee for Photometry, and M. de Haas president of the Advisory Committee for Thermometry. M. Lombardi was re-elected a member of the Advisory Committee for Electricity, and it was agreed that the International Electro-technical Commission should be consulted as to the two remaining vacancies. Messrs. Bordoni (Italy), Pirani (Germany) and Zwikker (Holland) were re-elected to the Advisory Committee for Photometry, and Messrs. Perucca (Italy), Timmermans (Belgium) and Zwietoslawski (Poland) were elected to the Advisory Committee for Thermometry.

The most important business before the International Committee arose from the recommendations of the advisory committees at their previous meetings in June 1939, in particular, that absolute electrical units, based on the M.K.S. (or the C.G.S.) system, should be substituted for the present international electrical units, based on the mercury ohm and the silver voltameter, and that a new unit of candle-power, based on the luminous intensity of a black-body radiator at the temperature of solidification of melted platinum (60 units per cm.^{2}), should be substituted for the present international candle, as from January 1, 1940.

As the International Committee had not met since these recommendations were made, it had not been possible to implement them at the date proposed. The Committee, having already been empowered to that effect by the General Conference of 1933, has now decided that these proposals should be put into force as from January 1, 1948, and notification of this decision is being sent to the Governments of all the States subscribing to the Convention. No difficulty arose with regard to the new unit of candle-power which, it is understood, has already been adopted in Germany. The decision in this case was unanimous. With regard to the proposed change in the electrical units, objection had been raised by the Physikalisch-Technische Reichsanstalt; but the Committee held that it was important that the decision on this question should not be further delayed, as unless the change were to be made soon it was likely to become increasingly difficult to make it at all. In this case the decision was that of a majority, with one dissentient.

The ratios of the principal international to the corresponding absolute electrical units accepted by the Committee are:

1 mean international ohm = 1·00049 ohm (absolute).

1 mean international volt = 1·00034 volt (absolute).

The recommendation of the Advisory Committee for Thermometry, that the calorie should be defined directly in terms of the joule, instead of by reference to the specific heat of water, was regarded as of less urgency and, as some objection had also been received to this proposal, it was agreed to defer a decision on it until the Advisory Committee had had a further opportunity of considering it.

OBITUARIES

Sir John Flett, K.B.E., F.R.S.

By the death of Sir John Smith Flett, British geology has sustained the loss of one of its most distinguished exponents, with an established reputation both at home and abroad. His career affords a remarkable example of the original research worker and able administrator, and his place is assured in the long line of distinguished geologists who have directed the work of the Geological Survey and Museum during the last 111 years.

Flett was born in 1869 in Kirkwall, Orkney, and was educated at Kirkwall Burgh School, then at George Watson's College, whence he proceeded to the University of Edinburgh. His academic career was prophetic in its brilliance and versatility, and was marked by the award of a unique and imposing array of prizes, medals and scholarships in the Faculties of Arts, Science and Medicine. He graduated M.A., B.Sc. (with honours in natural science) in 1892, M.B., C.M. in 1894, and spent a short time in medical practice. The urge towards geological work, however, was strong within him, and in 1895 he accepted the post of assistant to the professor of geology (then James Geikie) in Edinburgh, and very shortly afterwards was appointed lecturer in petrology. Concurrently with that post he held lectureships in geology at the Heriot-Watt College, the East of Scotland School of Rural Economy, and the School of Forestry in the Royal Botanic Garden. There followed six strenuous years of teaching, lecturing and research work resulting in part in the publication of two outstanding papers, "The Old Red Sandstone of the Orkneys" and "The Trap Dykes of the Orkneys", accepted in 1899 by the University of Edinburgh as a thesis for the D.Sc. degree.

Flett's reputation as a geologist and petrographer was steadily growing, and when, in 1901, the late Sir Jethro Teall relinquished the post of petrographer to become director of the Geological Survey and Museum, the young man from Scotland was offered and accepted the vacancy. He speedily made his influence felt. Familiar with the most recent methods of research, a skilled mineralogist, widely read in the literature of his subject, and possessed of energy, enthusiasm and a formidable capacity for constructive work, he set in motion a continuous flow of published reports, papers and contributions to official memoirs which permanently enhanced the reputation of the service to which he belonged. He

attracted to his laboratory many of the younger Survey men of his time. These he trained in his methods, and inspired and encouraged not a few of them to original research and subsequent distinction within and without the Survey. The output of his scientific work during this period was truly remarkable, comprising as it did petrographical contributions to no fewer than thirty official memoirs, the classic "Report on the Eruptions of the Soufrière in St. Vincent, in 1902, and on a visit to Montagne Pelée, in Martinique" (with Tempest Anderson), "The Geology of the Lizard and Meneage" (with J. B. Hill), and numerous contributions to scientific journals some of which were written in collaboration with his colleagues. In addition he contributed eighty-three petrological articles to the "Encyclopædia Britannica" (11th edition, 1910), and it is noteworthy testimony to the soundness and permanence of his work that thirty-three of these contributions appear in the 14th edition (1929).

In 1911 Flett succeeded the late Dr. John Horne as assistant to the director in Scotland, and thereafter became more and more immersed in Survey business and administration. He took an active and personal interest in every branch of Survey work, made extended visits to the field and familiarized himself with the numerous problems which constantly arise in the production and publication of geological maps and memoirs. The outbreak of war in 1914 caused serious depletion of the Survey staff, many of whom volunteered and were accepted for active service, and at the same time imposed on the director-ate new tasks and responsibilities in the search for, and assessment of, available resources of raw materials in short supply, and in meeting insistent demands for geological information relating to the sites of camps, training centres, aerodromes and factories at home and to military operations overseas. Flett tackled these new tasks with characteristic energy. He not only organised and directed the Scottish section of the work but also undertook a considerable amount of field investigation and made substantial personal contributions to the numerous reports prepared for the information of service and supply departments. His reputation as geologist, petrographer and administrator was now firmly established and fully justified his selection in 1920 to succeed the late Sir Aubrey Strahan as director of the Geological Survey and Museum, a post he filled with conspicuous distinction and success for fifteen years.

The record of achievement of the Geological Survey and Museum during this period is an impressive one. The arrears of work, an inevitable legacy of four years of war, were rapidly overtaken, the staff was enlarged and reorganised, district offices were established in the coalfields, and the work of bringing up to date and publishing the geological information relating to these vitally important areas was prosecuted with an unprecedented vigour and resulted in a steady outflow of maps, memoirs and special reports. Nor were the purely scientific aspects of geology neglected. The surveys of the great volcanic complexes of Mull and Ardnamurchan were completed and the results embodied in maps and memoirs which stand unrivalled as classic records of perhaps the most complicated structures ever mapped by the Geological Survey. Similarly, the extensive complexes of schist and granite of central and northern Sutherland were mapped and described, and the field survey of the Orkney and Shetland Islands was completed.

Throughout this period of strenuous activity Flett steadily pursued the scheme, proposed in 1912 by the Bell Committee, for the transference of the Geological Survey and Museum from the inadequate and congested accommodation in Jermyn Street to a new and more spacious building in South Kensington. The culmination of his efforts came in July 1935, when the King (then Duke of York) formally opened the new Geological Museum and Survey offices in Exhibition Road, and the institution, served so long, so devotedly and to such purpose, celebrated its centenary. Two months later Flett retired from the public service. In his retirement he continued with characteristic energy his geological pursuits and his deep interest in all matters connected with the Survey and Museum. He saw through the press his memorial volume, "The First Hundred Years of the Geological Survey", written during the last period of his directorship, revised the Lizard map and prepared a second edition of the memoir now being printed, and took the greatest pleasure in stimulating his colleagues and "his young men" to fresh endeavour for his beloved science. Active to the end, he died with startling suddenness in the garden of his cottage at Ashdon, Essex, on January 26.

Many honours came to Flett in the course of his long and brilliant career. He was a fellow of the Royal Societies of London and Edinburgh, Bigsby and Wollaston Medallist of the Geological Society, LL.D. of his own University, created K.B.E. in 1925, president of Section C of the British Association in 1921, president of the Mineralogical Society, and member and correspondent of numerous societies in the Dominions and foreign countries where he had travelled extensively. But what he valued most of all was the satisfaction of endeavour and achievement, and his name is permanently woven into the fabric of Survey history and tradition as a great geologist and a great director.

W. F. P. McLintock

Prof. George L. Funke

Prof. George L. Funke, professor of botany in the University of Ghent, died on December 15 at the age of fifty, after an operation. He was Dutch, born at The Hague on May 29, 1896, and was educated at Amsterdam and Utrecht. He graduated at the University of Utrecht in 1922 with a doctorate in botany and zoology. After some years as lecturer in Holland, he went in 1934 to Belgium as a lecturer at the University of Ghent, where he became an ordinary professor in 1937; during the War and the German occupation of Belgium, he was forced to go back to Holland, being deprived by the Germans of his post, which he resumed, however, in 1945.

Prof. Funke, who was unmarried, displayed an uncommon energy and an almost youthful enthusiasm in every kind of activity he took up; as director of the Botanical Laboratories at the University of Ghent, he paid much attention to the practical side of his work, and defended, at times against powerful odds, the teaching of biology in schools. His purely scientific work was of importance, particularly with regard to the question of the influence of the light on plant development. Inspired by the investigations of Dr. Frōschel, he developed a new branch of botanical science which may be called 'experimental plant sociology'; a book on this subject, it is expected, will shortly be published in the United States.

P. van Oye

Dr. Victor Robinson

THOSE who had known Victor Robinson only through his writings were unwilling at first, when they met him face to face, to associate this modest, hypersensitive, and extremely genial little man with so dramatic, fiery and sentimental a pen. Nevertheless, as a historian he was painstakingly accurate, being most scrupulous in going to the original sources.

The son of a medical man, Robinson was born in the Ukraine on August 16, 1886, emigrating to the United States of America in infancy. One of the first to specialize in the history of medicine in that country—he used to confess that his interest in the subject gave him the same sort of satisfaction as the devotee of hasheesh derives from his pipe—in 1912 he published one of his best known and most popular books, "Pathfinders in Medicine", for which he was hailed as the "Poet of Science". Eight years later he founded *Medical Life*, stated to be the first monthly journal of medical history in the English language. Specializing in valuable medico-historical symposia, at one period it served as the official organ of the American Society of Medical History. Beginning with the October 1922 issue the section on clinical medicine was eliminated. Its editorial board included such distinguished historians as Castiglioni, Comrie, de Lint, Ebstein, Neuburger, Sigerist, and Sudhoff. Robinson's last book, "Victory over Pain : a History of Anesthesia", was published in New York late last year, and it is interesting to be reminded that the author's first contribution to the literature of medical history was an article on "Simpson on Chloroform", and that his name was first listed in the "Index Medicus" under the heading of "Anesthetics".

Robinson was professor of the history of medicine at Temple University Medical School, Philadelphia, and lecturer on the history of nursing. He occupied a delightful apartment in New York's Greenwich Village. His medico-historical library was enviably complete, making him more or less independent of the City's reference libraries. Though an apparently facile writer, he was a tremendously hard worker, the German word *Sitzfleisch* being often on his lips. One of his most novel and entertaining essays appeared in the *Medical Review of Reviews* in 1929, describing his experiences with the fluid extract of hasheesh. In the introduction to "Pathfinders in Medicine", Victor Robinson characteristically admitted having entered the field of medical history as he had entered several others—out of curiosity. "But the fruit was tempting, and I have gathered it ever since."

W. R. BETT

NEWS and VIEWS

An International Trust for Zoological Nomenclature

IN view of the rapid growth in recent years in the volume of its work, the International Commission on Zoological Nomenclature (which is an unincorporated body of eighteen international commissioners elected by the International Zoological Congress) recently decided that an incorporated body should be formed for the purpose of managing its financial and other business affairs. For this purpose a body has now been incorporated under United Kingdom law with the title "International Trust for Zoological Nomenclature". At the same time an agreement has been made between the International Commission and the International Trust by which the Commission has transferred its assets to the Trust and the Trust has accepted responsibility for all the liabilities of the Commission. Under the new arrangements, the Commission will continue all its scientific functions, while the Trust will be responsible for publishing the Commission's "Opinions" and other publications, for meeting the administrative expenses of the Commission, and for carrying out such further developments as may be decided upon by the Commission. The full text of the instrument of incorporation will be published as soon as possible in the Commission's "Bulletin of Zoological Nomenclature".

The closest liaison between the Commission and the Trust is assured by arrangements under which the members of the Commission will be members of the Trust, and the secretary to the Commission will be *ex-officio* secretary to the Trust. In addition, the Trust has taken over, as its registered office, the premises at 41 Queen's Gate, London, S.W.7, hitherto occupied by the Commission as its publications office. In order to ensure that there shall at all times be a sufficient number of members available to attend meetings of the Trust, the Commission has arranged for the appointment as members of the Trust of certain of the honorary unpaid officials of the Commission. At the invitation of the Commission, the chairmanship of the Trust has been accepted by the Right Hon. Walter Elliot. The arrangements outlined above will provide the Commission with a strong administrative organisation and also enable it to concentrate the whole of its efforts upon furthering the orderly development of zoological nomenclature.

New University at Olomouc

THE difficulty of accommodating all students in the existing Czechoslovak universities has led to the opening of a new one at Olomouc in north Moravia. The ceremony took place on February 21 after a special train from Prague had brought President Beneš, members of the Czechoslovak cabinet, Sir Phillip Nichols (the British Ambassador) and other diplomatic personalities to Olomouc. The new university is named after Palacký, the Czechoslovak historian so long associated with both the Charles University and the National Museum of Prague ; and in his speech Dr. Beneš referred to the fact that Prague's university had existed for almost six hundred years, and that the name of Palacký could appropriately be given to the new university in recognition of the historian's cultural work for the nation a hundred years ago. He said that the importance of education is fully realized in Czechoslovakia, where it is vital for a small nation to be in the forefront of progress. The immediate task is to overtake the years lost through the War and the German occupation.

The rector of the new university is Prof. J. L. Fischer, a comparatively young philosopher from

the University of Brno, already well known on the Continent for his contributions to the modern philosophical approach to social problems. Perhaps better known in Britain is the dean, Dr. V. Lesný, previously professor of Oriental studies at Prague, who has travelled much in India and written several works on Indian culture, some of which have appeared in English. The best known of these is his study of Rabindranath Tagore. Olomouc is not a new centre of culture. It was the seat of an ancient Czechoslovak school in the sixteenth century. In the seventeenth century this became a catholic seminary, and its presses produced some early Slavonic books. The eighteenth century scientific journal, *Monatliche Auszüge*, edited by Joseph Petrasche, was published at Olomouc, then better known by its German name Olmütz.

Geology at University College, Swansea

It is announced that Dr. Duncan Leitch, at present lecturer in geology in the University of Glasgow, has been appointed to succeed Prof. T. Neville George as professor of geology at Swansea. Dr. Leitch was trained under the late Prof. J. W. Gregory, with whom he carried out researches on the metallic minerals of Kirkcudbrightshire and on some caves of Galloway. Most of his subsequent work has related to the palæontology and stratigraphy of the Carboniferous rocks, especially of Scotland, where in collaboration with Dr. John Weir he carried out an exhaustive study of the non-marine lamellibranchs of the Coal Measures and provided a sound basis for the correlation of the seams. In an important series of papers he has developed statistical methods, which are proving of wide application, for the study of fossils. There is great scope for statistical research in palæontology and in other branches of geology; and at Swansea, in close access to the areas where the standard sequence of Coal Measures zones was established, he will find good opportunities to extend these investigations.

Colonial University Grants Advisory Committee

The Secretary of State for the Colonies has, in accordance with a recommendation of the Commission on Higher Education in the Colonies, appointed a Colonial University Grants Advisory Committee to advise him on the expenditure of United Kingdom funds for the development of higher education in the Colonies. On the academic aspects the Committee will be guided by the opinion of the Inter-University Council for Higher Education in the Colonies. The secretary of the Inter-University Council, Mr. Walter Adams, has been appointed secretary of the new Committee also, and the following have been appointed members: Sir Hector Hetherington, vice-chancellor of the University of Glasgow (*chairman*); Miss Myra Curtis, principal of Newnham College, Cambridge; Lord Hailey; Sir James Irvine, vice-chancellor of the University of St. Andrews; Sir Walter Moberly, chairman of the University Grants Committee; Dr. Keith Murray, rector of Lincoln College, Oxford; Prof. D. Hughes Parry, vice-chancellor of the University of London; Dr. R. E. Priestly, vice-chancellor of the University of Birmingham; Mr. D. J. Sloss, vice-chancellor of the University of Hongkong; Mr. C. W. M. Cox, educational adviser to the Secretary of State for the Colonies; Mr. J. B. Williams, Finance Department, Colonial Office.

Experiments on Cosmic Rays in High-Flying Aircraft

A brief announcement has been issued by Dr. Gilbert Grosvenor and Dr. W. F. G. Swann in a News Bulletin of the National Geographic Society of Washington of some experiments on the origin of the meson component of the cosmic rays. The National Geographic Society, the Bartol Foundation and the U.S. Army co-operated in the experiments, which were made in a series of flights in a *B*29 aircraft at places, ranging from Northern Chile to Southern Canada, from the magnetic equator up to mag. lat. 48° N. and at altitudes up to 33,000 ft. The apparatus consisted of a number of coincidence counters arranged to record penetrating particles of which the direction of motion was in or near the vertical. The soft component (electrons and photons) was prevented from reaching the counters by a sufficient thickness of lead shielding. At 33,000 ft. the observed intensity of the mesons, using this particular experimental arrangement, was observed to increase by 33 per cent in going from mag. lat. 0° to mag. lat. 48°, and 50 per cent at 25,000 ft. The absolute change in intensity with latitude, in contrast with the above values of the relative changes, was greater at the higher altitude than at the lower.

The results show, in accordance with previous views, that a considerable fraction of the meson component is produced by primary charged particles, presumably protons, of such an energy that some of them are appreciably deflected by the magnetic field in approaching the earth. The decrease in the percentage variation of the intensity with latitude at increasing altitudes is attributed to the presence of a primary component which produces mesons in lead but is not sensitive to the magnetic field of the earth and is rapidly absorbed between 33,000 and 25,000 ft. This radiation could be made up of photons. The authors prefer, however, to attribute it to protons of great energy. In this case the observations suggest that the cross-section for the production of mesons by fast protons increases rapidly with increasing energy. In support of this view it is found that there is no increase in the meson intensity at 33,000 ft. at latitudes higher than 48° mag. N. A proton of such an energy that it could enter the earth's atmosphere at this latitude would not be stopped by the matter composing the atmosphere down to 33,000 ft. plus the lead of the apparatus if it loses energy only by the normal processes of ionization. The observed absorption must therefore be attributed to other processes which, the authors suggest, are connected with meson production.

Behaviour: An International Journal of Comparative Ethology

Interest in the study of animal behaviour (ethology) is growing rapidly. The results of comparative behaviour studies have in the past been scattered throughout a number of periodicals and other publications. The German *Zeitschrift für Tierpsychologie* was hitherto the only European journal devoted exclusively to the publication of modern behaviour studies; and during its short existence, it demonstrated clearly that a special journal of this kind fulfils a most important function in stimulating and promoting the study of the subject with which it deals; but its future is now in doubt. It has accordingly been decided to found a new international journal of comparative ethology to be called *Behaviour*.

The new journal will cover the scientific study of animal behaviour and will be open to reports of original research on animal behaviour and to theoretical papers calculated to promote the experimental study of the subject. Work on endocrinology and nerve physiology will be given its due share of space, so long as it is clearly related to and designed to illuminate the behaviour of the animal. The editors are Prof. H. Hediger (Basel); Prof. P. Palmgren (Helsingfors); Dr. W. H. Thorpe (Cambridge); and Dr. N. Tinbergen (Leyden). *Behaviour* will appear at first at irregular intervals in issues of about 160 pages, the frequency depending on the amount of material offered for publication and on the availability of suitable paper, etc. The price of a volume of about 320 pages will be about 20 Dutch guilders. It is being published by E. J. Brill of Leyden.

Cambridge Summer School in Metal Physics

A SUMMER SCHOOL in Metal Physics will be held during September 1–12 inclusive in the Cavendish Laboratory, Cambridge. The School will provide an introduction to the application of physical methods to the examination and utilization of metals, and is intended for those whose researches require a more fundamentally physical approach than is usual in ordinary metallurgical and engineering practice. The lectures and demonstrations will deal with (*a*) application of X-ray methods in the examination of metals, (*b*) physical and mechanical properties of metals. Both parts will be taken by all attending the School, and for part (*a*) an elementary knowledge of X-ray diffraction methods and of crystal symmetry will be assumed; during the School it will be possible to provide only a very brief review of these aspects of the subject-matter. A detailed syllabus and form of application for admission can be obtained from G. F. Hickson, secretary of the Board of Extra-mural Studies, Stuart House, Cambridge, to whom the completed application form should be returned not later than June 7.

University of Glasgow

THE bicentenary of the institution of a lectureship in chemistry in the University of Glasgow falls during the present session. Dr. William Cullen was appointed in 1747 and held the lectureship for nine years, being succeeded by Dr. Joseph Black in 1756. To celebrate the bicentenary, four lectures will be given in the Department of Chemistry, on May 9, 16, 23 and 30, by Dr. Douglas Guthrie, on "William Cullen and His Times"; Prof. John Read, on "Joseph Black, the Teacher and the Man"; Dr. Alexander Fleck, on "Scottish Industrial Development of the Cullen/Black Period"; Prof. A. R. Todd, on "Glasgow Chemistry in the Twentieth Century".

Society for Experimental Biology: Utrecht Meeting

THE Society for Experimental Biology is holding a meeting at Utrecht during April 11–14; this is the first foreign meeting which the Society has held. An invitation to hold the meeting in Utrecht was given by the botanists and zoologists of the University of Utrecht, on the initiative of Prof. G. J. van Oordt, who had been a visitor at the Society's meeting last year at Newcastle. Papers will be presented by both British and Dutch workers in the field of experimental biology. A party of about seventy British scientific workers will be visiting Utrecht for the meeting. Many topics will come under discussion, including some aspects of entomology and parasitology, histogenesis, electro-physiology, respiration of both animals and plants, permeability phenomena and plant hormones. On Sunday, April 13, there will be no formal sessions, but two expeditions, one to the reclaimed areas of the Zuider Zee, and the other to the bulb fields; on this evening, all those attending the conference will dine together at Amsterdam.

Servo-Mechanisms

A RAPIDLY growing literature gives some indication of the extent to which war-time developments of automatic control systems or servo-mechanisms are finding application in industry. These applications range from relatively simple remote-position control systems to the overall control of complete industrial processes. A specialized theoretical technique has been evolved for the design of such systems and the analysis of their behaviour. A number of papers on the various aspects of this subject will be presented at a Convention on Automatic Regulators and Servo-mechanisms to be held at the Institution of Electrical Engineers during May 19–23.

Announcements

DR. E. D. MERRILL, Arnold professor of botany at Harvard University, has been made an honorary staff member of the Botanic Gardens, Buitenzorg, Java. A diploma was handed to him by Dr. C. G. G. J. van Steenis, senior botanist of the Gardens, at a dinner for the editorial board of *Chronica Botanica* during the recent Boston meetings of the American Association.

THE Herbert Jackson Prize for 1946 of the London, Midland and Scottish Railway has been awarded to Mr. J. O. Cowburn, formerly engineering research assistant, Derby, for a paper entitled "The Development of a Successful Leakage-Testing Instrument for use on Vehicles fitted with the Automatic Vacuum Brake".

MR. WILLIAM WILLIAMSON, joint author of the Ray Society volumes "The British Hydracarina", vols. 1–3 (1925–29), has presented to the library of the Royal Society of Edinburgh more than a thousand papers and a number of volumes dealing with the Hydracarina. Specimens have been lodged with the Royal Scottish Museum, Edinburgh, the Department of Zoology of the University of Edinburgh, and the British Museum (Natural History), London.

THE X-Ray Analysis Group of the Institute of Physics has recently established an X-Ray Tube Panel, under the chairmanship of Dr. A. Taylor. The Panel will review existing and projected X-ray tubes and X-ray tube production in Great Britain. A questionnaire is being sent to all members of the X-Ray Analysis Group of the Institute and to certain others known to be interested in crystallographic X-ray tubes. Communications should be sent to the honorary secretary of the Panel, Mr. J. N. Kellar, Crystallographic Laboratory, Cavendish Laboratory, Cambridge.

ERRATUM.—In "Role of Sulphydryl Groups in the Action of Acetylcholine and Inhibition of the Vagus Nerve" by Prof. Ch. S. Koschtojanz and T. M. Turpajew published in *Nature* of December 7, 1946, p. 837, paragraph 5, last line, for "cystein" read "cystine".

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Determination of the Energy and Momentum of Fast Neutrons in Cosmic Rays

PREVIOUS experimenters, working on the multiple disintegration phenomena produced by cosmic radiations, have concluded that some at least of the nuclear explosions are produced by fast neutrons. In approaching the problem of determining the energy of such neutrons, we meet the difficulty that the usual method, in which observations are made on the recoil protons which the neutrons produce by collision with hydrogen nuclei, is not applicable. It is therefore important to develop alternative methods, and, for this purpose, we have examined the possibility of employing the nuclear reaction between boron and fast neutrons.

We first exposed boron-loaded plates to the homogeneous groups of neutrons produced by the bombardment of boron by 900 keV. deuterons from the Cambridge high-tension generator. Provision was made for determining the direction of the neutron flux at any point in the plate with an accuracy of $\pm 1°$, and the plates were placed in such a position that they were exposed to neutrons emitted in the direction of motion of the primary deuterons. In these conditions the mean energies of the fastest two groups of neutrons passing through the plates were 9·6 MeV. and 13·4 MeV. respectively.

A microscopic examination of the exposed plates after development shows, in addition to numerous short tracks due to the reaction

$$B^{10}_5 + n^1_0 \rightarrow Li^7_3 + He^4_2, \qquad (1)$$

many three-particle disintegrations. A photomicrograph of one of these events is reproduced in Fig. 1 (*a*). The discriminating power of the emulsion is sufficiently great to allow us to identify the tracks of two α-particles, α_1 and α_2, and a less heavily ionizing particle τ_1, composing the 'star'. We conclude that the disintegration is produced in the well-known reaction[1]

$$B^{10}_5 + n^1_0 \rightarrow He^4_2 + He^4_2 + H^3_1, \qquad (2)$$

of which the Q value, as determined from the masses of the nuclei, is + 0·4 MeV.

From the observed lengths of the tracks and the range-energy relation for tritons and α-particles in the emulsion[2], we can determine the energy of each of the particles. The values so obtained are: particle α_1, 7·4 ± 0·2 MeV.; particle α_2, 1·4 ± 0·4 MeV.; and triton (τ_1), 5·0 ± 0·1 MeV. The total energy is thus 13·8 ± 0·5 MeV., and this corresponds to an energy of the incident neutron of 13·4 ± 0·5 MeV. We can also compare the vector sum of the momenta of the three particles with that of the incident neutron, assuming the latter to have an energy equal to the mean energy of the fastest group of neutrons from the source. We chose the momentum of a proton of energy 0·5 MeV. as a convenient unit. The tracks of the three charged particles are nearly co-planar, and in Fig. 2 (*a*) we represent their momenta in a vector diagram. The resultant momentum is represented in magnitude and direction by the line OP, and this is nearly coincident with OR, the momentum of the incident neutron—the two magnitudes being 5·6 ± 0·6 units and 5·2 units respectively, and the difference in direction less than 2°. The errors in the determination of the total energy and momentum are mainly due to the uncertainty in the energy of the short-range α-particle, and they would be less if the ranges of the particles were more nearly equal.

In view of the satisfactory results obtained in work with neutrons of known energy and momentum, we next examined boron-loaded plates exposed to the cosmic rays, at the Pic du Midi, at a height of 2,800 m. We found a number of disintegration stars, very similar in form to those produced by the 13·4 MeV. neutrons; an example is reproduced in the mosaic of photomicrographs in Fig. 1 (*b*). From the grain-spacing in the tracks we can identify α_3 and α_4 as α-particles and τ_2 as a particle of charge $+e$. All the tracks end in the emulsion, so that their ranges can be determined; but, owing to the lack of an established range-energy relation extending up to 50 MeV., we can only deduce an approximate value of the energy of the particle α_3. By extrapolating the range-energy curve obtained in previous experiments, we obtain a value of 26·5 ± 1·5 MeV. The energy of particle α_4 is 2·9 ± 0·2 MeV. and, if τ_2 is a triton, its energy is 7·4 ± 0·1 MeV.

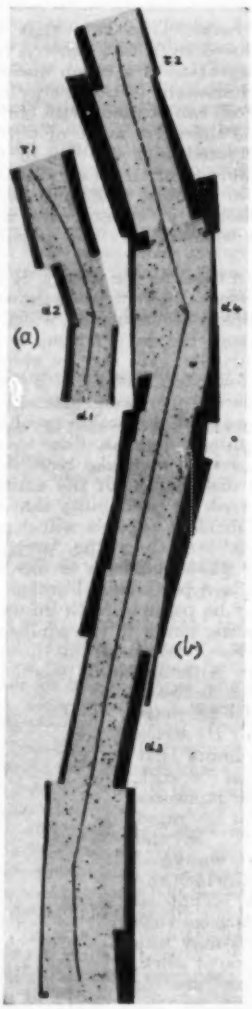

Fig. 1. THE BLACK EDGES OF THE INDIVIDUAL PHOTOGRAPHS HAVE BEEN RETAINED TO SHOW THE METHOD OF MAKING THE MOSAIC. THE PHOTOGRAPHS HAVE NOT BEEN 'RETOUCHED' AT ANY STAGE IN THE PHOTOGRAPHIC PROCESS

If we construct a momentum diagram, Fig. 2 (*b*), we find a value for the momentum of the incident particle of 9·5 ± 0·9 units. Assuming the particle to be a neutron, its calculated energy is 45 ± 8·5 MeV. as compared with the value, obtained from the total kinetic energy of the three particles, of 36·8 ± 1·8 MeV. If, alternatively, we calculate the mass of the incident particle from the observed energy and momentum, we obtain the value 1·23 ± 0·30 mass units.

In view of the uncertainty in the energy of particle α_3, and of the direction of particle α_4, the above result is

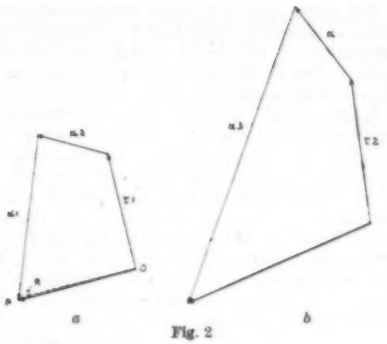

Fig. 2

very satisfactory and makes it certain that the disintegration was produced by a fast neutron and not by the photo-disintegration of a boron nucleus. We conclude that determinations of the energy and momentum of fast neutrons can be made with boron-loaded plates. Owing to the short range of tritons and α-particles, as compared with protons of the same energy, and the division of the energy among three particles, it may be possible, with thick emulsions, to apply the method in experiments with neutrons of energy up to 100 MeV. and possibly higher.

It must be anticipated that, as the energy of the intermediate nucleus increases, there will be a growing tendency for the proton and two neutrons, which at lower energies appear together as a triton, to be emitted as separate particles. It can be shown, however, that in very few cases will there be consistency between the observed energy and momentum if a star, produced in fact from a reaction involving neutron emission, is interpreted as due to reaction (2). In such cases, if we make reasonable assumptions about the distribution of the emitted neutrons, we can show that the probability that the calculated mass of the incident particle will depart from unity by amounts less than the 'probable error' is small. In the particular case of the star shown in Fig. 2 (*b*), it is 8 per cent. Further, in ambiguous cases, it may be possible, with improvements in the discriminating power of the emulsions, to distinguish the tracks of tritons from those of protons and deuterons. Although it is possible to get better discrimination between the various types of fast particles by using the *C*1, *E*1 and *D*1 series of emulsions, we have found that they cannot be employed for work in cosmic rays where long exposures are necessary because of the rapid fading of the tracks[2]. In the present experiments we employed *C*2 and *B*1 emulsions, in which the fading after a month is not so serious. We may emphasize that the other light elements may also be employed for this type of work. Beryllium and lithium are of particular interest because the modes of disintegration are simple.

The present results illustrate an important general feature of the photographic method. Because it is possible to determine the energy and the momentum of all the charged particles arising from the disintegration of a nucleus in the emulsion, the method is particularly suitable for the study of individual disintegrations, especially those in which more than two particles are emitted.

The investigation of the various modes of disintegration of boron under fast neutron bombardment, including an examination of the angular distribution of the disintegration particles, is continuing, and a complete account of the experiments will be published elsewhere.

We have pleasure in thanking Dr. W. E. Burchan and Mr. D. L. Livesey for their kindness in making it possible for us to obtain exposures to fast neutrons from the Cavendish high-tension generator. We are greatly indebted to Prof. J. Baillaud, director of the Observatory of the Pic du Midi, to Dr. Hugon and to Prof. Max Cosyns for assistance in obtaining the exposures to the cosmic rays. We wish to express our gratitude to Dr. C. F. Powell for many discussions, and for generous assistance.

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Jan. 16.

[1] Chadwick and Goldhaber, *Nature*, **135**, 65 (1935); *Proc. Camb. Phil. Soc.*, **31**, 612 (1935). Taylor, *Proc. Phys. Soc.*, **47**, 873 (1935).

[2] Lattes, Fowler and Cuer, *Proc. Phys. Soc.*, in the press.

Emission of Light Charged Particles in the Fission of Uranium

At the Physical Society's Conference on Fundamental Particles, held at Cambridge in July 1946, we reported that a light charged particle is occasionally emitted in the fission of uranium by slow neutrons, in addition to the two heavy fragments. This was observed during an examination of fission fragment tracks produced in Ilford photographic emulsions by a method which we have previously described[1]. Similar observations have recently been reported by Tsien, Chastel, Ho and Vigneron[2].

In a detailed investigation of this phenomenon, we have examined 25,000 fission tracks using emulsions which were sensitive to α-particles and heavier

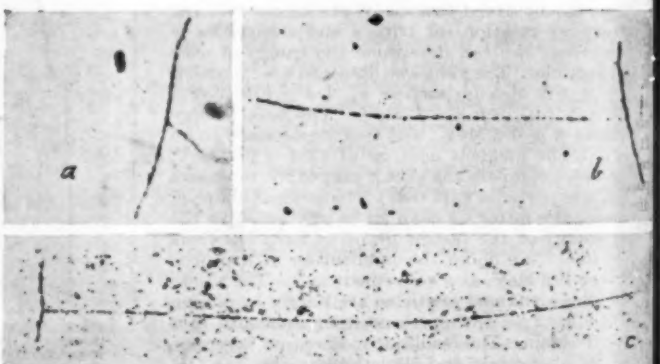

Fig. 1. (*a*) Light-particle range = 5·5 μ (0·87 cm. air equivalent). (*b*) Light-particle range = 53 μ (9·5 cm. air equivalent). (*c*) Light-particle range = 132μ (24 cm. air equivalent).

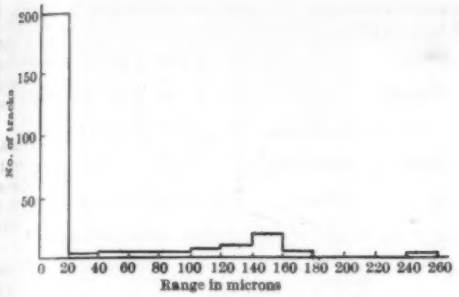

Fig. 2

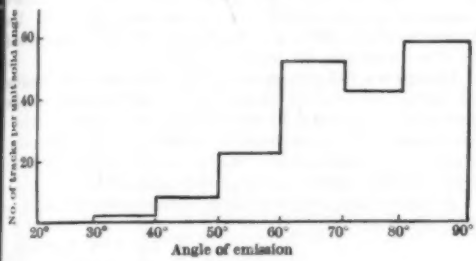

Fig. 3

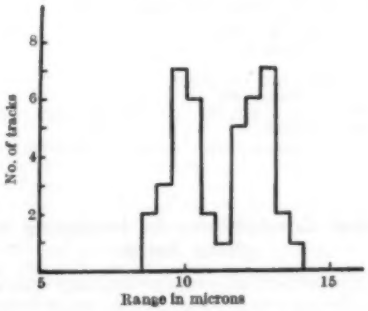

Fig. 4

ions but insensitive to protons. In cases where the emission of a third light particle was observed, measurements of the range of the particle and of the angle between its track and those of the heavy fragments were carried out. Typical examples of the tracks are shown in the photomicrographs, Fig. 1 *a*, *b*, *c*. The grain density in the light-particle tracks is consistent with the hypothesis that these particles are α-particles, although the possibility that they are nuclei of slightly greater mass cannot be excluded. It is, however, certain that the particles are not recoil nuclei projected by fission fragments in their passage through the emulsion, since the observed directions of emission are inconsistent with the momentum relations for such collision processes.

The range distribution of the light particles observed is shown in histogram form in Fig. 2; it shows that particles of all ranges from the lower limit of detection of 1·7 microns (2·8 mm. air equivalent) to a maximum in excess of 250 microns (45 cm. air equivalent) are present. A considerable number of particles fall into a short-range group; these particles had been detected previously in this Laboratory by coincidence counting methods[3]. The abundance of light particles of all ranges is 1 in 80 ± 4 fission events; for particles of range greater than 5 microns (equivalent to 8 mm. of air) it is 1 in 340 ± 30 fission events.

The angular distribution of the light-particle tracks has been determined, and is shown in Fig. 3, in which the number of tracks per unit solid angle is plotted against the angle between the direction of emission of the light particle and the fission fragment tracks. No significant difference between the angular distribution of the short-range and long-range particles has been detected. It is evident from Fig. 3 that the particles are emitted preferentially in directions nearly perpendicular to the fission fragment tracks.

Assuming that the third particle is emitted simultaneously with the two heavy fragments, its track defines the point of fission, and so the range distribution of the individual fission fragments in these events may be determined. The results of such range measurements give a distribution shown in Fig. 4, which refers to those events characterized by the emission of a long-range particle. The double peak of the distribution indicates that there is unequal division of mass in the modes of fission which produce light charged particles of high energy.

In the 25,000 fission events investigated, we have found no evidence of fission of the uranium nucleus into more than three charged particles.

We should like to thank Prof. N. Feather for much helpful advice. A more detailed account of the work will be published elsewhere.

L. L. Green
D. L. Livesey

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Cambridge.

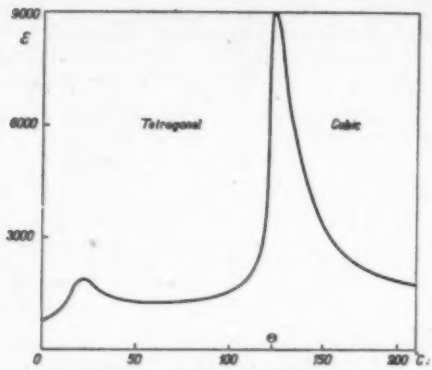
[1] Green and Livesey, *Nature*, **158**, 272 (1946).
[2] Tsien, Chastel, Ho and Vigneron, *C.R. Acad. Sci. Paris*, **223**, 986 (1946).
[3] Cassels, Dainty, Feather and Green, unpublished.

Effect of Temperature on the Permittivity of Barium Titanate

It is well known[1] that the dielectric behaviour of barium titanate and some mixed crystals of it with related compounds is quite different from most other materials (see accompanying illustration). At a certain temperature, θ, a very high value of the permittivity ε is found. On the left side of the peak, ε decreases with decreasing temperature though still some secondary maxima are found; on the high-temperature side of the peak, however, ε decreases monotonically.

According to Rooksby[2] and Miss Megaw[3], barium titanate shows an ideal cubic perovskite structure at temperatures above θ. In the neighbourhood of θ, a tetragonal distortion of the lattice takes place, persisting down to liquid–air temperatures.

In order to explain the permittivity–temperature curves in the cubic region, it has been assumed[4] that in these lattices permanent dipoles occur. At first sight this may seem reasonable, because for barium and lead titanates the ratio of the ionic distances is such as to allow a rather large space for the titanium ion. From electrostatic considerations it might be expected that the potential curve of the titanium ion would not show one minimum situated in the



DIELECTRIC CONSTANT OF BARIUM TITANATE AS A FUNCTION OF TEMPERATURE MEASURED WITH A.C. VOLTAGE OF 100 V./CM. AND A FREQUENCY OF 5 KC./S.

centre of the TiO_6 octahedron but several excentric positions of minimal energy.

By plotting $\frac{\varepsilon - 1}{\varepsilon + 2}$ against temperature in the cubic region, Rushman[4] derived a dipole moment of about $0{\cdot}1 \times 10^{-18}$ E.S.U., which seemed to be a plausible value in comparison with the magnitude of the dipole which is estimated from the free space available for the titanium ion.

In these calculations, however, the effect of thermal expansion has been neglected. This effect will cause a decrease of permittivity with increasing temperature.

We have tried to describe the dielectric properties by means of the Clausius–Mosotti formula :

$$\frac{\varepsilon - 1}{\varepsilon + 2} = \frac{4\pi}{3} n\alpha, \qquad (1)$$

where n is number of unit cells per cm.^{3} ; α is polarizability per unit cell (in the general case α may contain a dipole contribution).

From (1) the following expression for the temperature coefficient (T.C.) can be derived :

$$\text{T.C.} \equiv \frac{1}{\varepsilon}\frac{d\varepsilon}{dT} = \frac{(\varepsilon - 1)(\varepsilon + 2)}{\varepsilon}\left\{-\beta + \frac{1}{3}\frac{1}{\alpha}\frac{d\alpha}{dT}\right\}, \qquad (2)$$

where β is coefficient of linear expansion.

For TiO_2 (rutile) we found at room temperature experimentally a temperature coefficient of $-8{\cdot}3 \times 10^{-4}$, whereas the term $-\beta\frac{(\varepsilon - 1)(\varepsilon + 2)}{\varepsilon}$ calculated from β- and ε-measurements was found to be also $-8{\cdot}3 \times 10^{-4}$. From this we may conclude that here the temperature-dependency of α may be neglected.

In the case of high values of ε, (2) may be approximated by

$$\frac{1}{\varepsilon}\frac{d\varepsilon}{dT} = -\beta\varepsilon. \qquad (3)$$

From this it follows that

$$\frac{1}{\varepsilon} = \beta(T - C), \qquad (4)$$

which is exactly the hyperbolic law found by Rushman[4] in the cubic region of barium titanate (C is a temperature only slightly different from θ).

When the temperature curve for rutile and for some titanates in the cubic region is derived by means of formula (4), we find that the experimental data can be represented in a quite accurate way by formulæ of this type.

TiO_2	$\frac{1}{\varepsilon} = \{0{\cdot}73 \times 10^{-4}(T + 307)\}$
$BaTiO_3$	$\frac{1}{\varepsilon} = \{0{\cdot}98 \times 10^{-4}(T - 393)\}$
(Ba 0·70, Sr 0·30) TiO_3	$\frac{1}{\varepsilon} = \{1{\cdot}07 \times 10^{-4}(T - 306)\}$
(Ba 0·40, Sr 0·60) TiO_3	$\frac{1}{\varepsilon} = \{0{\cdot}90 \times 10^{-4}(T - 188)\}$
$SrTiO_3$	$\frac{1}{\varepsilon} = \{0{\cdot}96^5 \times 10^{-4}(T + 65)\}$

For β we found by expansion measurements

TiO_2	$0{\cdot}73 \times 10^{-4}$
$BaTiO_3$	$0{\cdot}95 \times 10^{-4}$
(Ba 0·65, Sr 0·35) TiO_3	$0{\cdot}98^5 \times 10^{-4}$

From this we may conclude that the α of these titanates is constant for temperatures above θ. The temperature coefficient appears to be a consequence of the variation of density only.

Hence we believe that in the temperature region of cubic structures there is no permanent dipole moment ; whereas in the tetragonal region where 'ferro-electric' phenomena (dependence on field strength, hysteresis) are observed, the assumption of such dipoles seems to be quite plausible.

A fuller account of these considerations will be published shortly.

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Jan. 6.

[1] Wul, B., *Nature*, **156**, 480 (1945).
[2] Rooksby, H. P., *Nature*, **155**, 484 (1945).
[3] Megaw, H. D., *Nature*, **155**, 484 (1945) ; **157**, 20 (1946) ; *Proc. Phys. Soc.*, **58**, 133 (1946).
[4] Rushman, D. F., Faraday Society meeting on dielectrics (1946).

Electrical Conductivity in Insulating Amorphous Solids

WE have carried out some preliminary experiments to find the current-voltage stress characteristics of soda-lime glass, this being taken as an example of an amorphous solid having the properties of an electrical insulator.

The conductivity stress relationships have been predicted theoretically by Dr. Fröhlich[1], and our conclusions would seem to be in agreement with his theory. Some previous workers[2] in the field of dielectric conductivity have restricted themselves to D.C. measurements of the conductivity, and their results have often indicated changes of conductivity with time (often over a period of minutes or hours). Other workers[3] have investigated the so-called 'breakdown voltage stress' and analysed their results statistically, thus producing valuable practical information.

We felt that there was considerable uncertainty in the definition of 'breakdown-stress', particularly as many workers insist on applying their stress for a definite time before 'breakdown' occurs. Believing that this breakdown may be either purely of an electrical nature, or purely of a mechanical nature due to change of state arising from thermal heating effects, we are investigating the conductivity of insulators at voltage stresses up to the 'breakdown' stress. It is thought that this will yield information

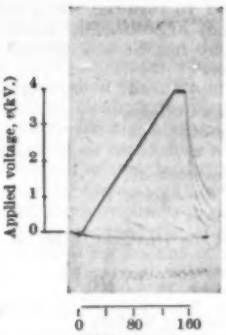

Fig. 1 *a*. APPLIED VOLTAGE WAVE-FORMS

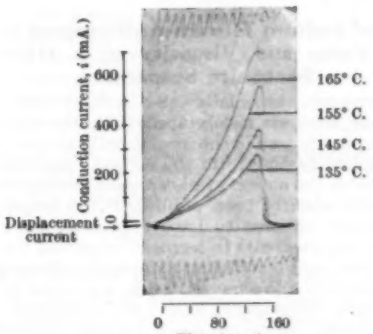

Fig. 1 *b*. CURRENT WAVE-FORMS

on the actual behaviour of conductivity before 'breakdown'.

In brief, our method was as follows. A small thin glass bulb blown at the end of a tube was filled with, and inserted in, mercury, thus providing two mercury electrodes. A single pulse the magnitude of which increased linearly with time for approximately 150 μsec. from zero up to 4 kV. max. was applied between the electrodes, and the sum of the displacement and conduction currents through the thin insulating bulb recorded at different temperatures by means of a recording cathode-ray oscillograph (see Figs. 1*a* and *b*). It will be seen that the conductivity increased with temperature, as was to be expected from the well-known law

$$\sigma = \sigma_0 \exp(-W/kT) \qquad (1)$$

applicable to low field strengths. The conductivity, however, also increases with applied field strength, the theoretical law[1] being

$$\log_e \frac{\sigma}{\sigma_0} = \frac{V_1}{\Delta V} \cdot \frac{1}{e} \cdot \frac{F^2}{F^{*2}} \qquad (F \ll F^*), \qquad (2)$$

where F^* is critical field strength, F is applied field strength, σ is conductivity, V_1, ΔV, σ_0 are constants, e is 2·73. Our practical arrangement did not allow us to determine σ or F absolutely, but gave figures proportional to each.

If the theoretical law (Equation 2) is true, then we expect to find

$$\log \frac{i}{v} = K_1 + K_2 v^2, \qquad (3)$$

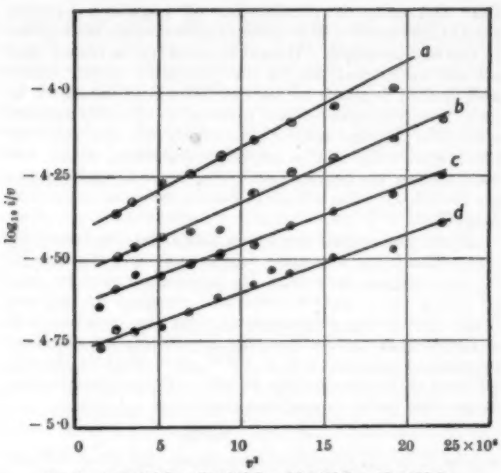

Fig. 2. (*a*) 165° C.; (*b*) 155° C.; (*c*) 145° C.; (*d*) 135° C.

where i is instantaneous current, v is instantaneous applied voltage, K_1, K_2 are constants.

$\text{Log}_{10}\, i/v$ is plotted against v^2 in Fig. 2, and a straight line results, apparently verifying the square law relationship in F of Equation 2.

It is believed that this method of approach to the problem of electrical conductivity in solids is new, and that it has a great advantage over previous methods of measuring conductivity at large field strengths, as it almost entirely eliminates complications due to heat generated in the specimen by the conduction current.

We are indebted to Dr. H. Fröhlich of the University of Bristol for a helpful discussion, and to Dr. D. M. Robinson for suggesting the investigation and the experimental method.

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Department of Electrical Engineering,
University of Birmingham.
Jan. 11.

[1] Fröhlich, H., E.R.A. Report L/T.153 (1945).
[2] Hubmann, *Ann. Phys.*, **9**, 733 (1931).
[3] Austin and Pelzer, E.R.A. Report, L/T.138 (1943).

Detectability of the Negative Proton

IT is customary to employ Dirac's equation to describe the proton, which is known to have spin ½. Therefore, it is to be expected that the negative proton should exist, though this particle has never been detected experimentally. In a study of the production and annihilation of negative protons[1], it was shown that it is not surprising that the particle has not been observed; but it was suggested that it could be observed, if certain cosmic ray experiments were improved. The calculations were based on the resolution of the field of a fast nucleon into a spectrum of mesons by the method of v. Weizsäcker[2] and E. J. Williams[3], and for simplicity account was taken only of the pseudoscalar mesons.

The problem has again been studied[4], account being taken not only of the pseudoscalar mesons of the Weizsäcker spectrum but also of its longitudinal and transverse mesons, in accordance with the Møller–Rosenfeld form of the meson theory[5]. It is found

that the rate of production of negative protons should be three or four times smaller than that given in the earlier paper. However, it must be noted that all the numerical results are probably upper limits and should perhaps be two to five times smaller. In fact, the densities of the mesons in the Weizsäcker spectrum depend rather sensitively on the value of the lower limit of the impact parameter, which has been taken to be the Compton wave-length of the nucleon $\hbar/Mc$, but which in reality may be somewhat larger[6].

When the negative proton has been produced by the collision of a cosmic ray meson and a nucleon, it may escape detection by producing mesons and so losing its negative electrical charge. It appears from cosmic ray experiments that the cross-section φ for meson production by a proton, or negative proton, is at least $4{\cdot}6 \times 10^{-26}$ cm.^{2}, that is $(\hbar/\mu c)^2$, where μ is the mass of the meson[7]. The corresponding mean free path in nuclear matter is

$$\tau = 1/N\varphi,$$

where N is the number of nucleons the total volume of which is equal to 1 cm.^{3}. Taking the radius of the lead nucleus to be $1{\cdot}1 \times 10^{-13}$ cm., one obtains

$$N = \frac{3 \times 207 \times 10^{39}}{4\pi \times 1{\cdot}1^3}, \text{ so that } \tau = 6 \times 10^{-13} \text{ cm.}$$

Hence the maximum value of the mean free path of the negative proton in nuclear matter is about four times the average distance between the nucleons in a nucleus.

Assuming that the mean free path is approximately equal to the average distance between two nuclear particles, one may estimate what is the probability that a negative proton will escape from the nucleus where it has been formed without losing its negative charge. It will lose its charge if it collides with a nucleon, and that will certainly happen unless it has been produced in the surface layer. However, even in the case of a large nucleus such as lead, most of the nucleons are in this layer. If the negative proton has been produced on the surface, then there is roughly a 50 per cent chance that it will not collide with a nucleon. Thus the process of meson production in the nucleus will scarcely reduce the probability of detecting the negative proton by more than a factor 3.

When a negative proton has emerged from the nucleus, it may be lost to observation by producing mesons in the surrounding material. Its mean free path is less than 4 cm. of lead, which corresponds approximately to one thirtieth of the atmosphere. So a negative proton formed by the collision of a cosmic ray meson and a nucleon in the atmosphere will not come down to sea-level unless it has been produced in the lowest one thirtieth of the atmosphere. This considerably reduces the chance of observing the negative proton in sea-level cosmic radiation; hence with the present experimental technique it is very unlikely that the particle could be detected by examining the charge of the particles which cause the heavy tracks in cloud-chamber photographs.

If one studies the production of negative protons by the passage of mesons with energy greater than 4×10^9 eV. through a lead plate of 1 cm. thickness and allows for the loss by meson production, one finds that at least one hundred thousand mesons would have to penetrate before one negative proton would be formed. Thus a long series of experiments would now be required to observe the particle; though, when the present experimental methods have been improved, it may not be too difficult to detect the negative proton.

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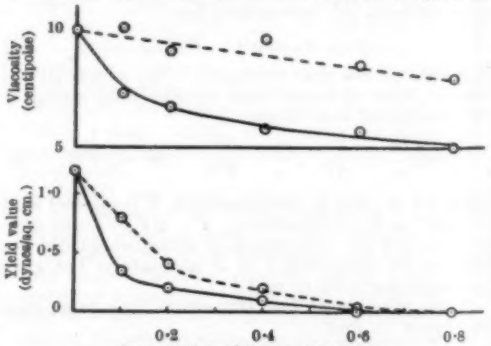
[1] McConnell, J., *Proc. Roy. Irish Acad.*, A, **50**, 189 (1945); cf. *Nature*, **158**, 280 (1946).
[2] *Z. Phys.*, **88**, 612 (1934).
[3] *Kgl. Dansk. Vid. Selsk.*, **13**, 4 (1935).
[4] McConnell, J., *Proc. Roy. Irish Acad.*, in the press.
[5] *Kgl. Dansk. Vid. Selsk.*, **17**, 8 (1940).
[6] Cf. Heitler, W., and Peng, H. W., *Proc. Roy. Irish Acad.*, A, **49**, 109 (1943).
[7] Cf. Heitler, W., and Walsh, P., *Rev. Mod. Phys.*, **17**, 252 (1945).

Effect of Sodium Hexametaphosphate on the Yield Value and Viscosity of a Hydrogen Bentonite Suspension

Phosphates, especially the sodium hexametaphosphate, are now widely applied for the treatment of drilling muds used in the rotary drilling of oil-wells[1]. Some papers dealing from the colloid chemical point of view with the action of phosphates on clay suspensions have recently been published[2]. A majority of investigators appears to have expressed the results of their measurements in terms of apparent viscosity and to have paid insufficient attention to the progress of the reaction. We have tried in our work to overcome these objections, and have obtained some results which seem to need further explanation. Results of detailed investigations will be published elsewhere; but the preliminary observations appear to be sufficiently interesting to be communicated here.

We have used a rotary viscometer designed by Mukherjee and Sen Gupta[3]. Various quantities of a sodium hexametaphosphate solution were added to a 12 per cent aged hydrogen bentonite suspension, prepared by electrodialysis, and the requisite quantities of water were added to make the suspensions 10 per cent in every case. Viscometric measurements were made using the suspensions just after addition of the phosphate, and then at intervals up to a period of twenty days. 'Initial' and 'final' yield values and viscosities (obtained from graphical extrapolation) are shown in the accompanying figure.



Full curve, immediate (initial); broken curve, after 20 days (final)

It appears from the graph that the phosphate has a greater effect in reducing the yield value than the viscosity. The more important observation which was not quite expected is that, while the viscosity increases on standing, tending to reach the original figure, the yield value for the higher concentrations of phosphate (0·6–0·8 per cent) does not increase on standing up to a period of twenty days. The results cannot be explained by assuming that the phosphate ion is fixed by aluminium or enters the clay complex; for while this would account for the reversion of viscosity to the original figure, the constancy of the yield value seems to be at variance with this hypothesis.

We acknowledge our indebtedness to Mr. K. D. Bhabock for his collaboration in the experimental work.

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[1] Evans, P., and Reid, A., *Trans. Min. Geol. Inst. India*, **32**, 3 (Dec. 1936).

[2] Loomis, A. G., Ford, T. F., and Fidlam, J. F., *Petroleum Tech.*, T.P., 120 (May 1940). Garrison, A. D., and ten Brink, K. C., *Petroleum Tech.*, T.P., 1124 (Nov. 1939).

[3] Mukherjee, J. N., and Sen Gupta, N. C., *Indian J. Phys.*, **16**, 66 (1942).

Theory of Molecular Coupling in Polar Liquids

In 1939 I published[1] a general outline of the theory of the phenomena of molecular orientation in polar liquids. During the War I have generalized and worked out this theory in more detail.

Four effects of molecular orientation have been considered: (i) dielectric polarization, (ii) dielectric saturation in a strong electric field[2], (iii) electric birefringence (Kerr effect), and (iv) magnetic birefringence (Cotton – Mouton effect). The only liquid in which all these effects have been thoroughly examined is nitrobenzene. Fig. 1 represents the experimental results for nitrobenzene and its solutions in non-polar solvent (benzene). R, R_S, R_K and R_{CM} are 'reducing factors' corresponding to these effects respectively. Reducing factors are defined as the ratio of a 'molar constant', for example, molar polarization $P^{dip} = \frac{4\pi N \mu^2}{9\,kT}$, calculated for a liquid or its solution, to the same 'molar constant' (for example, P^{dip}_{gas}), determined for the same substance in the gaseous state. The calculation is based on the assumption of the validity of the Lorentz formula for the local field.

I have also applied the Onsager field[3] to the calculation of molar constants for these four effects from experimental data. The corresponding reducing factors are plotted in Fig. 2 against the number of dipole molecules per cm.^{3} of solution, as before. The curves show a quite different type of variation from that of the Lorentz field. First, the 'molar constants' are not constant, in disagreement with what might be expected on the basis of Onsager's theory. Further, the increase of R and R_K observed for higher concentrations indicates that a new kind of molecular coupling (kind III) must be considered to explain this behaviour.

In the paper quoted above[1], I assumed two kinds of coupling forces. The coupling of kind I is that of Fowler – Debye[4,5] due to the combined action of a great number of surrounding molecules. The coupling of kind II consists in the transitory formation of unstable and non-rigid pairs with the nearest neighbouring molecule. The theory based on these assumptions gives only a qualitative agreement with the Lorentz curves represented in Fig. 1. It explains in particular the change of sign of R_S and the fact that R_{CM} is greater than unity[6]. It is impossible, however, to obtain a quantitative agreement between the theory and the full set of Lorentz curves given in Fig. 1.

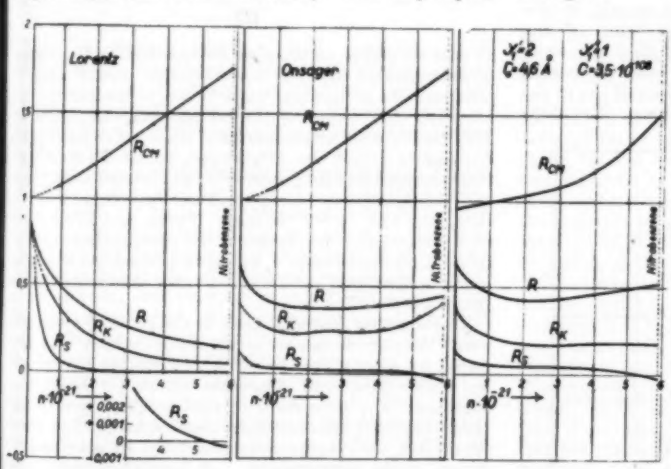

Fig. 1 Fig. 2 Fig. 3

Fig. 1. Reducing factors calculated from experimental data using the Lorentz local field

Fig. 2. Reducing factors calculated from experimental data using the Onsager local field

Fig. 3. Theoretical reducing factors calculated assuming the existence of three kinds of coupling forces. To be compared with Fig. 2

I was able to obtain a reasonable quantitative agreement between theory and experiment using the Onsager local field and assuming in addition the above-mentioned coupling of kind III. This coupling results from the mutual interaction of the transitory quasi-antiparallel pairs formed by the coupling of kind II. The total electric moment is thus increased.

It is significant that the agreement between the theory and experiment is assured for all four phenomena considered by one set of four constants common to all the formulæ. The theoretical curves are shown in Fig. 3, in which the numerical values of the constants are also given. Comparing the experimental curves (calculated on the basis of Onsager's local field, Fig. 2) with the theoretical ones (Fig. 3), it can be seen that many characteristic features of the experimental curves are well reproduced by the theory.

Recently, I calculated on the same assumptions the lowering

of the freezing point of dilute solutions of polar liquids in non-polar solvents. Agreement with the experimental data has been obtained without introducing any new constant.

A full account of this work will be published elsewhere.

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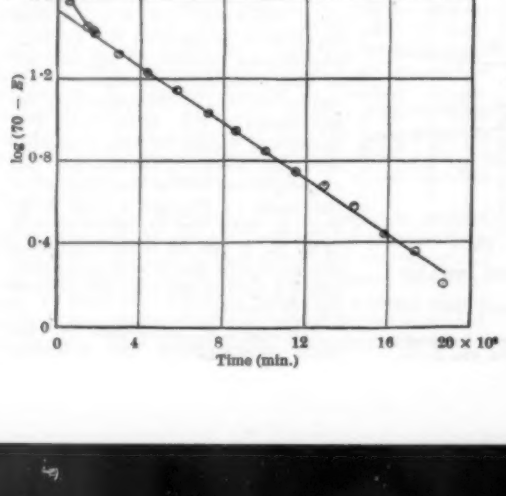
[1] Piekara, A., *Proc. Roy. Soc.*, A, **172**, 360 (1939).
[2] Piekara, A., and Piekara, B., *C.R. Acad. Sci., Paris*, **203**, 852 (1936) *Phys. Z.*, **38**, 671 (1937).
[3] Onsager, L., *J. Amer. Chem. Soc.*, **58**, 1486 (1936).
[4] Fowler, R. H., *Proc. Roy. Soc.*, A, **149**, 1 (1935).
[5] Debye, P., *Phys. Z.*, **36**, 100 (1935).
[6] Vide König, H., *Ann. Phys.*, **31**, 289 (1938).

Structure of the Keratin Molecule

WHEN wool fibres of uniform cross-sectional area are stretched extremely slowly in saturated air at 18° C., they break at 70 per cent extension[1]. Confined in its early stages to the amorphous regions of the fibre, extension occurs by the transformation of the crystalline phase from the α- to the β-configuration at extensions above about 25 per cent[2]. It has been found possible to disentangle these two processes, and obtain a closer insight into the α-β-transformation process, by studying the extension of wool fibres under constant *stress*[3] in saturated air at low temperatures. Under a stress of $6{\cdot}89 \times 10^8$ gm./cm.^{2} at 21° C., for example, the immediate extension of the fibre (3 minutes after the application of stress) was 19·4 per cent, rising to 30·2 per cent after 300 minutes and 68·4 per cent after 18,682 minutes. As might be expected, there is an exponential approach to the limiting extension of 70 per cent, as shown in the accompanying figure, where log $(70 - E)$ is plotted against time.

Since the linear relationship is not obeyed in the early stages, where extension occurs mainly in the amorphous phase, and since extrapolation of the line indicates an initial extension of 35·6 per cent, it is clear that extension of the fibre over the period from 1 to 13 days is due to slow unfolding of the molecules of α-keratin in the crystalline phase. The slope



(k) of the line in the figure is a measure of the rate of unfolding, and by determining k at different temperatures with wool fibres under various stresses, the activation energy associated with the α-β-transformation can be calculated.

Under a stress of $6{\cdot}89 \times 10^8$ gm./cm.^{2} at 21° C. and 13° C., the values of k were $6{\cdot}76 \times 10^{-5}$ and $2{\cdot}65 \times 10^{-5}$, respectively, corresponding to an activation energy of about 20 kcal. This, in turn, agrees with Astbury's conception[4] of the nature of the intramolecular fold in α-keratin, for the opening of each fold involves the breakdown of three hydrogen bonds between —CO— and —NH— groups.

Determinations of the rate of extension of wool fibres under constant stress thus provide a simple and attractive means of studying the structure and reactivity of α-keratin, and the above experiments are now being extended to wool and other fibres under a wide variety of conditions.

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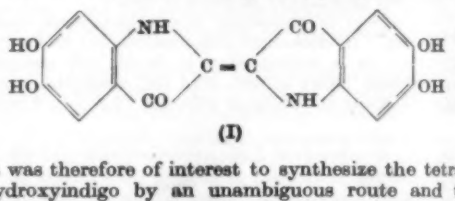
[1] Speakman, *J. Text. Inst.*, **17**, T457 (1926).
[2] Astbury and Street, *Phil. Trans. Roy. Soc.*, A, **230**, 75 (1931). Astbury and Woods, *Phil. Trans. Roy. Soc.*, A, **232**, 333 (1933).
[3] Speakman, *J. Text. Inst.*, **17**, T472 (1926).
[4] Astbury and Bell, *Nature*, **147**, 696 (1941).

Constitution of Melanin

IT has been suggested recently[1] that 5 : 6 : 5′ : 6′-tetrahydroxy-indigo (I), or a quinone or semi-quinone derived from it, is an important constituent of melanin, the black pigment produced by the oxidation of tyrosine and 3 : 4-dihydroxyphenylalanine[2].



(I)

It was therefore of interest to synthesize the tetrahydroxyindigo by an unambiguous route and to compare its properties with those of melanin. An attempt to synthesize the compound was made by Hayduck[3], who unsuccessfully tried to demethylate a product which he considered to be 5 : 6 : 5′ : 6′-tetramethoxyindigo; however, he showed later[4] that the tetramethoxy compound in question was, in fact, the 6 : 7 : 6′ : 7′ isomer. Clemo and Weiss (*loc. cit.*) attempted to remove the methylene groups from piperonal-indigo; but this procedure was also unsuccessful, only products insoluble in aqueous alkali being obtained.

The starting material used in the present synthesis was 6-nitroprotocatechuic aldehyde, which was prepared by Parijs[5] by the action of fuming nitric acid on 6-nitropiperonal diacetate in acetic anhydride solution. On repetition of this work it was found that the yields obtained were much smaller than those described, and the process could not be adapted for larger scale preparation. 6-Nitro-piperonal was found to be remarkably resistant to demethylenation by the usual methods, but it was eventually found that the methylene group could be removed successfully by heating with an excess of pyridine hydrochloride to 160–170°, and this appears to be the only practicable method.

When the disodium salt of 6-nitroprotocatechuic aldehyde was treated with two molecules of chloromethyl ether in benzene, 3 : 4-bis-(methoxymethoxy)-6-nitrobenzaldehyde was obtained, and this compound on treatment with acetone and alkali gave 5 : 6 : 5′ : 6′-tetra(methoxymethoxy) indigo in good yield. Hydrolysis with dilute mineral acid then yielded the required tetrahydroxyindigo. The product was a greenish-black powder, slightly soluble in pyridine and nitrobenzene with a greenish-blue colour. It was readily soluble in aqueous sodium hydroxide giving an intense permanganate-violet solution, and was reprecipitated unchanged by addition of acid. Acetylation with acetic anhydride and pyridine gave the tetra-acetyl derivative which crystallized well from nitrobenzene. On reduction with sodium hydrosulphite and alkali a yellow vat was obtained, re-oxidizing readily in air to give a violet solution.

The tetrahydroxyindigo is thus quite different from melanin, which is slightly soluble in alkali with a greenish-brown colour. Furthermore, it is scarcely possible that melanin can be a quinone or semi-quinone derived from tetrahydroxyindigo, since such a compound would undoubtedly be reduced by sodium hydrosulphite and alkali to the same leuco-compound as that formed from the tetrahydroxyindigo itself: this latter is certainly not obtained from melanin, as the hydrosulphite vat from this substance does not re-oxidize to give the characteristic violet colour shown by alkaline solutions of the tetrahydroxyindigo.

Full details of this work will be published elsewhere in due course.

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[1] Clemo and Weiss, *J. Chem. Soc.*, 702 (1945).
[2] Raper, *Biochem. J.*, **21**, 89 (1927); **31**, 2162 (1937).
[3] *Ber.*, **36**, 1528 (1903).
[4] *Ber.*, **36**, 2930 (1903).
[5] *Rec. Trav. Chim.*, **49**, 18 (1930).

The interesting method used successfully by Harley-Mason for demethylenation is similar to that worked out in Germany[1] during the War using pyridine hydrochloride for the demethylation of phenol ethers, which was unknown to us at the time of our work.

The conclusions reached in our paper were largely based on the determination of the oxidation equivalents by H. S. Raper. Accepting Raper's figures, the indigoid formulation suggests itself as the most likely one on the basis of our experiments and on the known behaviour of dihydroxyindole. As implied in our paper, and bearing in mind the marked instability of catechol compounds under biological *p*H conditions, it is very unlikely that the hydroxyl groups are present in the free state.

If, on the other hand, one admits higher oxidation figures than those given by Raper, then clearly there is the possibility of polymerization products of indigoid type, for example, with a dehydrotype as polymerizing unit.

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[1] Prey, V., *Ber.*, **75B**, 350 (1943).

Existence of Cupric Hexammino Sulphate

While the hexammino compounds of the halides, nitrates and other salts of copper are well known, nothing seems to be on record regarding the existence of cupric hexammino sulphate. In recent communications, Dey and Bhattacharya[1] have described a new method for the isolation of cupric pentammino sulphate, from ammoniacal solutions of cupric sulphate. In other publications from this laboratory, Dey has recorded the results of the conductometric measurements of mixtures of cupric nitrate[2] or chloride[3], with ammonium hydroxide solutions, of various compositions. The conductometric curves gave breaks corresponding to three, four, five and six molecules of ammonia for one molecule of the copper salt, thus affording the evidence for the existence of tri-, tetra-, penta- and hexa-ammino cupric compounds. In the case of cupric ammino sulphates, however, the triammino compound is not found, whereas the three other compounds are formed. The changes in the extinction coefficients of mixtures have also been studied by means of a Nutting's spectrophotometer, and the results confirm those obtained by the electrical conductivity method. We thus find that these results indicate the definite existence of cupric hexammino sulphate, as well, in an ammoniacal solution of cupric sulphate.

I am indebted to Dr. A. K. Bhattacharya, head of the Department of Chemistry, University of Saugor, for his interest in this work.

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[1] Dey and Bhattacharya, *Curr. Sci.*, **14**, 201 (1945); *Proc. Ind. Acad. Sci.*, A, **23**, 259 (1946).
[2] Dey, *Nature*, **158**, 95 (1946).
[3] Dey, *Curr. Sci.*, **15**, 317 (1946).

Statistical Methods in Chemical Analyses

It is well established that many of the distributions met in biological work approximate to the normal, and the modern developments of statistics are associated with this fact. Most of the techniques are dependent for their validity, to a greater or less extent, on the goodness of the normal equation as a description of the experimental distributions. Since there cannot be any *a priori* reasons for expecting distributions in chemical work to be normal, and there seems to have been very little investigation of the natures of the distributions actually occurring, application of methods which presume normality may be highly dangerous.

With the view of ascertaining whether such methods can be applied, I have carried out an investigation of a number of distributions arising in the course of analysing chemically a wide variety of the products of industry in the Chemical Inspection Department of the Ministry of Supply. The products included metals, alloys, 'pure' and 'commercial' chemicals, mixtures, etc., from thirty or forty different firms. Some 250 distributions, involving about 50,000 chemical analyses, have been examined. The analyses were of various kinds, such as determinations of impurities present as traces or in larger amounts, assays of substances both pure and crude, and measurements of characteristics, by chemical and physical methods, such as are ordinarily carried out in the control laboratories of chemical industry.

It was found that only 10–15 per cent of these distributions could, for practical purposes, be regarded as normal. The remainder were significantly non-normal. Some 15 per cent of the distributions were of the form of truncated normal curves. These may, of course, be treated as the tails of normal curves which can be fitted either (i) graphically, (ii) by Pearson's method of the moments about the stump, or (iii) by a least squares method which has been developed.

About 10 per cent of the distributions were symmetrical ($\beta_1 \doteq 0$) but showed leptokurtosis ($\beta_2 > 3$) to an appreciable extent, and the χ^2-test for the goodness of fit of a normal equation gave values of $P < 0{\cdot}01$. Thus they could not be described satisfactorily by equations of the normal form. Fitting of curves, such as Pearson's Type III, did not prove to be entirely satisfactory. A mathematical model, which is the sum of the products of two Poisson distributions, has been worked out, and it seems that distributions of this type may usefully be described by the equation

$$y_x = I_{|x|}(\sigma^2) \cdot \exp(-\sigma^2),$$

in which $I_{|x|}(\sigma^2)$ is a Bessel function of the second kind.

Since $|x|$ is used, the curve is symmetrical about $x = 0$ and extends from $-\infty$ to $+\infty$. The integral is unity, and hence the expression may be used as a probability distribution.

The lower moments of this distribution are $\mu_2 = \sigma^2$; $\mu_3 = 0$; $\mu_4 = 3\sigma^4 + \sigma^2$, and the coefficients $\beta_1 = 0$ and $\beta_2 = 3 + \frac{1}{\sigma^2}$.

Since

$$\sigma_\sigma = \frac{\sigma}{\sqrt{2n}} \left(1 + \frac{\beta_2 - 3}{2}\right)^{1/2},$$

we have for the standard deviation of the standard deviation of this distribution

$$\sigma_\sigma = \frac{\sigma}{\sqrt{2n}} \left(1 + \frac{1}{2\sigma^2}\right)^{1/2}.$$

The expression in brackets differs from unity by more than five per cent when $\sigma^2 = 5$. Hence, for large samples, the usual expression for the standard deviation of the standard deviation cannot be used when $\sigma^2 < 5$. In the actual distributions studied, it has been found that the degree of leptokurtosis is considerably greater than this. The position in regard to small samples is being investigated.

Some 10 per cent of the distributions were truncated leptokurtic curves apparently derived from the above parent distribution.

About 20–25 per cent of the distributions were J-shaped. It has been found that many of these may usefully be described by an equation of the form

$$y_x = \frac{1}{\sqrt{2\pi . ax}} \left(\frac{\bar{x}}{x}\right)^{ax} \cdot \exp a(x - \bar{x}),$$

the parameters of which can readily be calculated.

Some 20–25 per cent were skewed. Some of these may be treated by logarithmic or other transformations of the variable, but these methods are not entirely successful. A promising approach to a generalized equation for this type of curve is now being explored. This equation is of the form

$$y_x = \left(\frac{\sigma^2 + \bar{x}}{\sigma^2 - \bar{x}}\right)^{x/2} \cdot I_{|x|}\left(\sqrt{\sigma^4 - x^2}\right) . \exp(-\sigma^2),$$

of which the lower moments are

$$\mu_2 = \sigma^2; \ \mu_3 = \bar{x}; \ \mu_4 = 3\sigma^4 + \sigma^2.$$

The remainder of the distributions were irregular. A few were bi-modal and have yielded to analysis into the sum of two normal distributions.

From the data under consideration it has been possible to associate certain types of chemical data with the above different kinds of distribution.

The principal conclusions of this investigation are: (1) great caution must be exercised in applying the ordinary simple statistical methods to the data of chemical analysis; (ii) many of the distributions depart radically from the normal and are possibly more correctly to be regarded as forms of 'rare occurrence' distributions; (iii) the continuous nature of the variable is, in many cases, probably superficial, and it should, more correctly, be regarded as a discontinuous variable.

It is hoped shortly to publish this work in full elsewhere. I wish to express my appreciation to Prof. H. Levy and Prof. H. V. A. Briscoe for advice and encouragement, and to the Chief Scientist, Ministry of Supply, for permission to publish the work.

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Transference of Vitamin D from the Female Rat to Her Young

No report has been found of the ability of the rat to transfer ingested vitamin D to the milk. The ability to do this is known to be limited in the human being[1,2,3,4], in the cow[5,6] and in the ewe[7]. An accidental and most unfortunate experience in this laboratory has provided a certain amount of information on the transmission of vitamin D from the diet to the milk of the rat.

The diet of the stock colony of rats[8] contains 10 per cent of full-cream dried milk powder. Litters intended for vitamin D tests are weaned at 21–23 days of age and fed on the stock diet until they are 55–65 gm. in weight, that is, for about ten days. If they are then given the Steenbock rachitogenic diet (2,965)[9] for a preparatory period of three weeks, they develop a severe degree of rickets and are suitable for use in determinations of vitamin D. A further period of ten days on the same diet together with a small dose of the standard or vitamin-containing substance results in the formation of a line of healing in the metaphyses of the ulnæ and radii with well-defined areas of uncalcified cartilage above and below it.

In August 1945 the healing as evidenced in the 'line test' gradually became very high, and by the end of September the bones showed very little signs of development of rickets after four and a half weeks on the rachitogenic diet. As short periods of apparent inability to produce rickets had previously been encountered, possible causes and methods of counteraction were explored with negative results. As the rats were kept during this period in a basement room illuminated solely by artificial light, the effect of excessive daylight suggested by previous experience to be the most probable cause of trouble was ruled out. The fresh cow's milk and liver were withheld from the diet of the stock colony, but with no apparent effect on the rachitic condition of the young when given the rachitogenic diet. In fact, it was

observed that rats fed on the rachitogenic diet grew well and showed obvious signs of well-being. Moreover, in place of the usual seasonal drop in the number of litters produced by the colony in the later months of the year, the reproduction-rate was well maintained. At the end of December it was discovered with dismay that the dried milk used in making the stock diets for the breeding colony had been fortified by the producers with vitamin D. Deliveries in August, September and October were acknowledged to have been fortified; earlier ones were not determined. Assuming the vitamin D content of the milk to be 10 I.U. per gm. as now claimed for all 'National dried milk', an animal consuming 15 gm. of stock diet daily would thus be receiving about 15 I.U. of vitamin D a day.

The fortified milk was, of course, replaced by unfortified at the beginning of January 1946. The reappearance of rickets in young rats fed on the rachitogenic diet was followed by putting on fresh litters each week and examining some rats of each, week by week for six weeks, by the 'line test' technique. A mild degree of rickets began to develop in the young rats about the end of February, and the rachitic condition gradually became more and more severe until at the beginning of May it was severe enough to use the rats for vitamin D determinations after the usual three weeks preparatory period. During the later part of this long time of examining 'no dose' rats, a few cases of apparently spontaneous healing were observed; but on investigation it was found that the rats in which it occurred had eaten the greater part of one of their number while they had been housed all together in one cage. The healing in these rats may have been brought about by the ingestion of residual vitamin D in the eaten rat or of part of its skeleton, which might have been enough to upset the Ca : P ratio of the diet and bring about healing independently of the presence of vitamin D.

It might have been expected that, as soon as unfortified dried milk was again given to the colony, the young rats would develop the usual intensity of rickets when given the rachitogenic diet. They would surely have done so if the source of their vitamin D had been only the stock diet they had eaten between weaning and receiving the rachitogenic diet. However, successive litters of young rats, taken from stock week by week and prepared as described, developed no rickets at first, and only as time went on developed at first a mild degree of rickets, then a more severe condition, and finally after about four months a state of rickets comparable with that we had previously produced by the same treatment. This indicated clearly that the young rats must have obtained supplies of the vitamin from the doe, either via the placenta or from the milk during lactation, and stored it somewhere for use as needed. The severity of the rickets developed in the different litters after four months of unfortified dried milk in the stock diet did not vary much, and we were able to proceed with the determination of vitamin D in the usual way.

It is tempting to try to estimate the adult doe's need of vitamin D from this experiment, but there are too many unknown factors in it. The amount of vitamin D taken in by the does during the four months when the diet contained fortified dried milk was probably more than 2,130 I.U. (that is, 15 I.U. a day for 142 days from the dried milk, and an unknown amount, though small, from the rest of the diet). But there is no indication of how much of this was absorbed or stored or used up by the rat while she was being fed on the enriched diet. She certainly had stored some of it, but there is no indication of what her store was when unfortified dried milk was again given in the diet. We only know that the store was exhausted within a further four months, during which each doe probably had two litters and gave to her young decreasing amounts of vitamin D as time went on. That the doe would probably benefit by receiving more vitamin D than the stock diet usually contains is indicated by the fact already mentioned that the breeding of the colony (as evidenced by the number of litters born) was higher during the winter months of 1945–46 than in any previous winter of the colony's existence.

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College of the Pharmaceutical Society,
London. Jan. 21.

[1] Drummond, J. C., Gray, C. H., and Richardson, N. E. G., *Brit. Med. J.*, ii, 757 (1939).
[2] Barnes, D. J., Cope, F., Hunscher, H. A., and Macy, I. G., *J. Nutrit.*, **8**, 647 (1934).
[3] Lewis, J. M., *New York State J. Med.*, **34**, 685 (1934).
[4] Polskin, L. J., Kramer, B., and Sobel, A. E., *J. Nutrit.*, **30**, 451 (1945).
[5] Steenbock, H., Hart, E. B., Hanning, F., and Humphrey, G. C., *J. Biol. Chem.*, **86**, 197 (1930).
[6] Van Niekerk, J., and Hofstra, H., *Tijdschr. Diergeneesk.*, **66**, 454 (1939).
[7] Kirk, W. G., *Iowa State Coll. J. Sci.*, **13**, 235 (1939).
[8] Coward, K. H., Cambden, M., and Lee, E. M., *Biochem. J.*, **26**, 679 (1932).
[9] Steenbock, H., and Black, A., *J. Biol. Chem.*, **64**, 263 (1925).

Heat Treatment and the Biological Value of Soya-bean Protein

FROM the observations of other workers[1–13], it appears that the increase in biological value in heat-treated soya-bean may be due to three reasons: (1) heat treatment increases the availability of cysteine and methionine due to some change in the structure of the protein; (2) proteolytic inhibitor is inactivated by heat treatment; (3) any toxic factor which may be present other than the inhibitor is destroyed by heat.

The present study was conducted to see whether heat treatment is essential for improving the biological value of soya protein. For this purpose pure glycinin was separated from defatted soya-bean and its nutritive value compared to that of raw bean. The extraction was carried out at *p*H 7·0 with 6 per cent sodium chloride, and the aqueous extract was dialysed and precipitated further by bringing down the reaction to *p*H 4·2. The precipitated glycinin was centrifuged out. The biological value of glycinin and the proteins in raw and autoclaved soya-bean were compared by determining the growth in young albino rats over a period of eight weeks. The protein was fed at 10 per cent level. The results obtained are as follows:

Source of protein	Protein consumed (gm.)	Gain in weight (gm.)	Gain in weight (gm.) per gm. protein consumed
Raw soya-bean	29·1	22·6	0·78
Glycinin	31·5	48·8	1·55
Autoclaved soya-bean (15 lb. for 1 hr.)	30·6	44·7	1·46

The results show that heat is not essential for enhancing the nutritive value of the protein in raw

soya-bean as the glycinin is more effective in promoting growth than autoclaved soya-bean.

The proteolytic inhibitor and also any toxic factor which may be present in raw soya-bean are eliminated in the process of preparing glycinin. This is supported by the observation that the acid extract of soya-bean retards the growth of rats provided with a well-balanced diet.

Further studies are in progress to determine the nature and mechanism of action of the factors present in the extract.

Our thanks are due to Prof. V. Subrahmanyan for his interest in the work.

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[1] Hayward, J. W., Steenbock, H., and Bohstedt, G., *J. Nutrit.*, **11**, 219 (1936).
[2] Shrewsbury, C. L., and Vestel, C. M., Bull. 420, Purdue Univ., Agric. Exp. Sta. (1937).
[3] Johnson, L. M., Parsons, H. T., and Steenbock, H., *J. Nutrit.*, **18**, 423 (1939).
[4] Hayward, J. W., and Hafner, F. H., *Poultry Sci.*, **20**, 139 (1941).
[5] Everson, G. J., Steenbock, H., Cederquist, D. C., and Parsons, H. T., *J. Nutrit.*, **27**, 225 (1944).
[6] Wilgus, H. S., Norris, L. C., and Heuser, G. F., *J. Ind. Eng. Chem.*, **28**, 586 (1936).
[7] Mashino, M., *J. Soc. Chem. Ind. Japan*, **32**, 256B (1929).
[8] Kajisuka, S., *J. Soc. Chem. Ind. Japan*, **38**, 746B (1935).
[9] Waterman, H. C., and Johns, C. O., *J. Biol. Chem.*, **46**, 9 (1921).
[10] Ham, W. E., and Sandsteet, R. M., *J. Biol. Chem.*, **154**, 505 (1944).
[11] Ham, W. E., Sandsteet, R. M., and Musschl, F. E., *J. Biol. Chem.*, **161**, 635 (1945).
[12] Melnick, D., Oser, B. L., and Weiss, S., *Science*, **103**, 326 (1946).

Solvent-treated Cellulose Acetate as the Stationary Phase in Partition Chromatography

Silica gel and cellulose have a wide application as stationary aqueous adsorbents in partition chromatography, the moving phase being an organic solvent. For many purposes a stationary organic phase is desirable, and the use of solvent-treated organic polymers to serve as supporting media for organic solvent phases has, therefore, been investigated.

Cellulose acetate, as ¼-in. staple filaments, when treated with *n*-butyl alcohol at 50° C. for thirty minutes, cooled, filtered, pressed and washed with saline to remove excess solvent, serves as a stationary organic solvent phase. 50 gm. of this material, packed tightly in a column, was sufficient adsorbent to extract exhaustively cresol and benzoic acid from 2 litres of an aqueous 0·1 per cent cresol solution, saturated at room temperature with benzoic acid, and with addition of sodium chloride. The extracted organic substances could be eluted with aqueous alkaline eluents or by a suitable organic solvent such as ether.

A. E. Aréa Leão *et al.*[1], in the extraction of penicillin from culture media filtrates, used a suspension of "solvent-activated cellulose acetate" prepared by shaking an aqueous suspension of cellulose acetate with addition of a small proportion of suitable solvent, for example, chloroform. A chromatographic method was not used by them, and it is possible that the new technique described might prove to be an improvement on the usual solvent extraction procedure.

In general, suitable adsorbents may be prepared by treating the polymer with a solvent swelling agent at a temperature just below that required to cause aggregation of the swollen polymer particles. Cellulose acetate may be regarded as the prototype of a wide range of polymers that could be utilized in the manner described. W. Coltof[2] may be consulted for comprehensive data on the effect of solvents on cellulose acetate. A wide industrial application of this technique to solvent-water partitions is obvious.

I wish to thank British Celanese, Ltd., for generous gifts of polymers used in this department, and for information.

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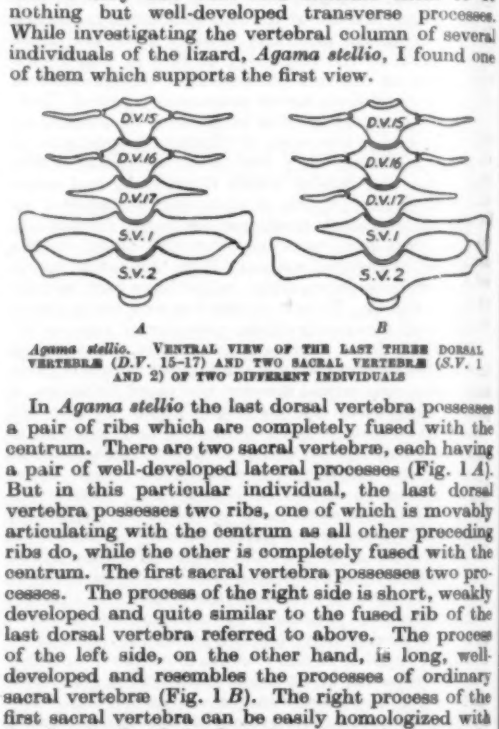
Jan. 16.

[1] Aréa Leão, A. E., *et al.*, *Rev. Brasil Biol.*, **5**, 149 (1945).
[2] Coltof, W., "Acetate Silk" (Amsterdam, 1934), reviewed in *J. Soc. Chem. Ind., Lond.*, **56**, 39, 891 (1937).

Sacral Ribs of Lacertilia

Some authors consider the lateral processes of sacral vertebræ in Lacertilia to be fused sacral ribs. Others deny this view and consider them to be nothing but well-developed transverse processes. While investigating the vertebral column of several individuals of the lizard, *Agama stellio*, I found one of them which supports the first view.



Agama stellio. Ventral view of the last three dorsal vertebræ (*D.V.* 15–17) and two sacral vertebræ (*S.V.* 1 and 2) of two different individuals

In *Agama stellio* the last dorsal vertebra possesses a pair of ribs which are completely fused with the centrum. There are two sacral vertebræ, each having a pair of well-developed lateral processes (Fig. 1 *A*). But in this particular individual, the last dorsal vertebra possesses two ribs, one of which is movably articulating with the centrum as all other preceding ribs do, while the other is completely fused with the centrum. The first sacral vertebra possesses two processes. The process of the right side is short, weakly developed and quite similar to the fused rib of the last dorsal vertebra referred to above. The process of the left side, on the other hand, is long, well-developed and resembles the processes of ordinary sacral vertebræ (Fig. 1 *B*). The right process of the first sacral vertebra can be easily homologized with the fused rib of the last dorsal vertebra, and the same is, then, true for the left process.

Therefore, the lateral processes of the sacral vertebræ of Lacertilia should be considered as sacral ribs which have fused with the centra of their vertebræ, and which have become greatly enlarged so as to perform the important function of supporting the pelvic girdle.

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ASPECTS OF STRUCTURAL ENGINEERING

THE Bossom Gift Lecture for the current session, forming part of the programme of public lectures arranged by the Chadwick Trust, was delivered on November 26, 1946, at the Institution of Structural Engineers by this year's president of that body, Prof. H. J. Collins, Chadwick professor of engineering at University College, London. Under the title of "Some Aspects of Structural Engineering", Prof. Collins dealt broadly with the post-war building situation in Britain, with special reference to the report of the mission (on which Sir Alfred Bossom, who presided at the meeting, had served) which visited the United States of America in 1943, to the present policy of the Government on housing, and to the 'avalanche of paper' in the form of building studies, codes, standard specifications and revised regulations with which those who design and construct in these days are expected to comply. Having but recently resumed civilian duties after five years of active service in the Royal Engineers, Prof. Collins chose to refer by question rather than by answer to certain aspects of building and constructional engineering which marked the contrast between post-war and pre-war years.

Prof. Collins said that six non-constructive, indeed extremely destructive, years had brought the urgency of the need for building to a tremendous pitch, intensified by the general desire that social conditions should in the process be improved. Domestic housing is undoubtedly of the first importance; it is necessary to employ as economically as possible both labour and material, and to devise substitutes for all materials which are not indigenous. Types of construction other than housing are also urgently needed. When work on these is resumed:

What will be the effect, on the progress of construction, of uncertainties both as to construction dates and as to the loads and stresses which will then be permissible?

The economical use of materials is a measure of the skill of the engineer, but it takes from five to ten years to train a civil engineer, and none was being trained during the last three years of the War. It is therefore more than ever necessary to keep the knowledge of trained engineers up to date.

Are the results of advances in research being made readily available to the engineer?

The supreme achievement in structural design is to attain simplicity approaching functional perfection. Under State control, the tendency might well be away from simplicity, but the attempt might nevertheless be made to overcome the shortage of engineers by standardizing methods of design. To control design by legislation must tend to change its governing principle from individual initiative and considered thought to rampant empiricism, and so put an end to scientific progress.

How far can standardization be carried without tending to kill initiative? Should the establishment of such standards as might be necessary be made the responsibility, not of a Government department, but of the appropriate engineering professional institution?

Ruskin showed that ancient building was often made wonderful by the marriage of science and art. Is the light of the Seven Lamps of Architecture so dim to-day, asked Prof. Collins, as to need the further illumination of some 174 building studies, codes and standards?

Can studies, codes and regulations do away with the need for independent architects and for properly qualified structural engineers?

A national policy governing the design and construction of buildings must be based on one of two alternatives: either it might allow any person to call himself an engineer, control him by regulations, and maintain conformity to these by a system of inspectors: or it might restrict the making of designs to selected persons of proved competence, and insist that such persons be qualified by institutional examination and/or by registration. Hitherto, standards of qualification for inspectors and systems of inspection in different parts of the country have varied considerably.

Could we accept as sound a national uniform set of building regulations? Would registration act more for the national good or for the benefit of one or more groups of professional men?

Prof. Collins recalled his experiences in 1939, when he assisted in forming Construction and Artisan Works Companies of the Corps of Royal Engineers from 600–800 building craftsmen who had answered the urgent call for volunteers in the Christmas broadcast of that year. He had served with those men in three theatres of war and lived with them for five years. By their training as apprentices, they had been made amenable to suggestion; because of the pride each felt in his craft they required little supervision; because they were used to working under the supervision of foremen they accepted discipline automatically. If the spirit of these volunteer craftsmen were present in the building industry to-day, then delays in production must come from other causes than their lack of willingness to deliver the goods.

In the course of general post-war increases in wages in the building industry, perhaps semi-skilled workmen and labourers had been unduly favoured at the expense of the more highly skilled workmen.

Were the post-war differences between the wages of craftsmen and of unskilled labourers sufficient to offset the drawbacks and hardship involved in the long apprenticeship required of the skilled trades?

In conclusion, Prof. Collins referred briefly to the present position of research in relation to modern building, and mentioned several promising lines of possible development: the use of photogrammetry in town and country planning, the application to structural engineering of electrical methods of measuring strains which have proved successful in the aircraft industry, and the application of supersonic frequencies to the measurement and consolidation of materials.

The outstanding work which has been done and is still being done by the Government research departments, and by the institutions which they sponsor, should be supplemented by a pool of apparatus for research purposes, and by grants of fellowships to men who, by combining with research a limited amount of teaching, would hand on knowledge both of facts and methods to a wide circle. These considerations led to his last question.

In post-war reconstruction and planning, are the universities and technical colleges playing their full

part in the advancement of building science and of research in structural engineering ?

Some of Prof. Collins' questions were purely rhetorical, and indicated no doubt as to the answer he might have given: others would be difficult indeed to answer at the present time; but all referred to problems which demand solution, and were aimed at stimulating thought and decision in those who must either take a lead in directing the future or perforce follow the direction of others less reticent.

Reading between the lines of Prof. Collins' questions, it is not difficult to trace the hope he had expressed with less reserve in the conclusion to his presidential address to the Institution of Structural Engineers a few weeks previously, that the "young members will in the future live to see the sun rise over the unshackled initiative of structural engineers; engineers who carry no fetters of Government regulation, no manacles of Local Authority restriction; but who have the free and unchecked initiative to plan and design that belongs by right to members of a profession that bears such heavy responsibility to society and to mankind".

STANLEY B. HAMILTON

ANTIBIOTICS

THE number of publications which record work on antibiotics has become so large that frequent evaluations of the progress of our knowledge of these substances have become essential. A conference devoted to these substances was held by the New York Academy of Sciences in January 1946, and the papers have now been published (*Ann. N.Y. Acad. Sci.*, **48**, Art. 2, 31; 1946). It is impossible to summarize these papers here, but a note on them will indicate their scope. They are arranged in two sections, one microbiological, the other pharmacological.

Dr. S. A. Waksman introduces the former with a paper on the contributions made by the microbiologist. M. J. Johnson describes the metabolism of penicillin-producing moulds, and K. B. Raper discusses the development of improved forms of them. W. J. Robbins, F. Kavanagh and Annette Hervey discuss the production of antibiotic substances by Basidiomycetes, S. A. Waksman, A. Schutz and D. M. Reynolds write on the production of antibiotic substances by Actinomycetes, and J. W. Foster and H. B. Woodruff deal with antibiotic substances produced by bacteria.

The pharmacological section is, with the exception of an article on the pharmacology of penicillin by G. Rake and A. P. Richardson and one on its use in the United States Navy by W. W. Duemling, devoted to the pharmacology of streptomycin and streptothricin. The first article on this subject is by H. Molitor. In another article H. J. Robinson discusses the absorption, excretion and chemotherapy of these two substances. The action of streptomycin on various micro-organisms and its use for the treatment of some non-tuberculous infections are discussed by E. Pulaski, A. Kleinman and G. G. Duncan. Its action on the bacillus of tuberculosis has given rise to the hope that it will be useful for the treatment of this disease; but the article here printed by H. C. Hinshaw and W. H. Feldman on the use of streptomycin for the treatment of clinical and experimental tuberculosis emphasizes the opinion expressed in an "Annotation" in the *British Medical Journal* (906, Dec. 14, 1946), that "it is at present quite uncertain whether streptomycin will prove, in the long run, to have great therapeutic value in tuberculosis". The same "Annotation" announces that committees appointed by the Medical Research Council will, when enough streptomycin becomes available, conduct trials of streptomycin for the treatment of types of tuberculosis likely to give clear evidence of its uses and limitations, and also trials of its action on certain non-tuberculous infections. The same cautious opinion of its possible efficacy for the treatment of tuberculosis is expressed by Dr. P. D'Arcy Hart in his Mitchell Lecture delivered to the Royal College of Physicians (*Brit. Med. J.*, 805, Nov. 30, and 849, Dec. 7, 1946) on the "Chemotherapy of Tuberculosis", a remarkable lecture with a full bibliography, which is discussed in an editorial article in the *British Medical Journal* (862, Dec. 7), together with the Harben Lectures on the same subject delivered by Dr. W. H. Feldman, of the Mayo Clinic. An interesting recent paper by D. G. Madigan, P. N. Swift and G. Brownlee (*Lancet*, 9, Jan. 4, 1947) indicates that what these authors call "the potential and actual toxicity of streptomycin" needs to be watched and investigated further.

Brief reference may also be made to the address given to the American Chemical Society in October of last year by Dr. L. C. Craig, of the Rockefeller Institute for Medical Research. Dr. Craig described a new method of isolating various forms of penicillin which frees the chemist from dependence upon boiling and melting points. This method, which is called 'counter-current distribution', uses the partition coefficient, which is a ratio indicating the diffusibility of a substance into cell protoplasm. The method employs a system of multiple transfers of the substance being studied through a series of separating funnels, so that the mathematics of the binomial theorem may be applied to interpret the results. Dr. Craig claimed that the method has disclosed at least seven types of penicillin and has indicated that there are many more. The method has also been applied to synthetic antimalarial substances.

G. LAPAGE

CANADIAN RESEARCH IN GEODESY AND GEOPHYSICS

THE National Research Council of Canada has re-organised its Associate Committee on Geodesy and Geophysics (formed in 1945) and has given it authority to gather information on, and to direct and co-ordinate research in the field of, "geodesy and geophysics, including meteorology, hydrology, oceanography, seismology, vulcanology, magnetism, terrestrial electricity, tectonophysics, gravity, and any other subjects necessary to an integrated study of earth physics and geophysical prospecting". The chairman of the Committee is Prof. J. T. Wilson, professor of geophysics, University of Toronto.

The Committee is being provided with funds for the award of grants in aid of specific research projects to persons competent to direct work in this field and who have the required laboratory facilities at their disposal. Much of the work that interests the Committee is carried out as part of their normal duties by several Government departments and is paid for by those departments.

The integration and stimulation of geophysical work in Canada are desirable for several reasons: (i) geophysical methods of mineral and oil prospecting have assumed great importance, and this will continue; (ii) the Pre-Cambrian shield is the biggest and richest area of basement rocks in the world, and its study will throw light on earth structure as well as provide minerals; (iii) there are large areas of potentially useful oil-bearing rocks in western Canada; (iv) no other country is in so interesting a position geophysically, since Canada includes the north magnetic pole, and extends to the north geographic pole, and nearly to the magnetic axis; a larger part of the maximum auroral belt crosses Canada than any other country; (v) ionospheric studies for radio prediction have increased greatly during the War, and there are seven Canadian stations; the auroral belt will always produce peculiar effects; (vi) magnetic observations are lacking in northern Canada, where they are of value for navigation and of great interest near the magnetic pole.

More than a score of projects have already been initiated and further investigations are planned. One of the most fruitful subjects aided by the Committee has been the development of an airborne magnetometer. Fluxgate magnetometers were built by the National Research Council during the War; but these, it was known, would require extensive modifications before they could be adapted to airborne use. An early type was fitted to aeroplanes flying on Exercise Musk-Ox, in order to gain experience. In the United States, the Geological Survey had succeeded in adapting to geological use the magnetic airborne detector used in anti-submarine work, and it was thought this instrument would be suitable for use in Canada. The National Research Council obtained three sets from the United States Navy and modified them so that they will be available to the Department of Mines and Resources for use in Canada during the summer of 1947. Arrangements were made for a United States Geological Survey crew to bring a magnetometer to Canada and to make trial magnetic surveys of part of the Sudbury basin and of Louvicourt township. These surveys have been calculated, and the results will be published by the Geological Survey of Canada in co-operation with the United States Geological Survey.

In another project, mining and prospecting companies in Canada have co-operated with the Committee by supplying plans of magnetic readings for some of their properties. The Bourlamagne region in Quebec was chosen as a suitable area on which a regional map might be prepared from the magnetic survey data supplied by mining companies. Magnetic data for five townships have now been compiled and contoured. Comparison with the geology of the area will be made in a report now being prepared for publication.

A seismic study of the crust of the earth using rock-bursts as a source is projected for this season.

Geophysical work will continue to be done and paid for by existing departments, companies, and universities; but all this work will now be co-ordinated by the Associate Committee on Geodesy and Geophysics of the National Research Council. The Committee's work will not overlap that of the Geophysical Committee of the Geology Division of the Canadian Institute of Mining and Metallurgy, which deals with matters such as assessment laws, customs and tax rates, methods of procedure and professional ethics.

Steps have been taken to hold open meetings of the Associate Committee on Geodesy and Geophysics, the first of which was in connexion with the annual meeting of the Canadian Institute of Mining and Metallurgy at the National Research Building in Ottawa on January 23, 1947. The Committee proposes also to start publishing a bibliography on Canadian geophysics which will include reports on its activities.

RELAXATION METHODS APPLIED TO ENGINEERING PROBLEMS

IN this latest instalment* of Dr. R. V. Southwell's application of his relaxation method for the solution of the differential equations of physics, the problems treated are of a kind which are particularly intractable by classical methods—problems relating to the flow of a fluid having one or more free surfaces in a gravitational field. In addition to their practical interest, the results obtained present in an acute form the fundamental question of the extent to which the numerical approach can disprove the possibility of a particular type of solution.

When the relaxation method reveals the existence of a hitherto mathematically unknown flow pattern (as it does in this paper in connexion with the wakes formed by entrained air behind a cylinder or sphere travelling through a fluid), it can be shown that this solution satisfies all the required conditions, and is therefore authentic. But when the computation fails to reveal the existence of a solution which on general grounds might be expected to exist, to what extent is it proved that no such solution does in fact exist? Such a case arises in this paper in the treatment of the stream-line distribution caused by the passage of an inclined plane of infinite width over the surface of a fluid of finite depth. Apparently, in this two-dimensional problem it is impossible for the depth of the fluid to be the same before and after the passage of the plane—a result which may appear to be contrary to expectation. Perhaps the best approach to this question is to regard the relaxation method as an experimental rather than as a mathematical technique. The authors repeatedly stress the tentative nature of the relaxation process, and perhaps their results can be seen in the proper perspective if they are regarded as experiments carried out, as real experiments so seldom are, under ideal mathematical conditions. The failure of such an experiment to reveal a certain phenomenon does not disprove its existence; but a sufficient number of such experiments, carried out under various conditions, and all giving a negative result, may be taken as demonstrating that the phenomenon does not occur in practice—which for the engineer is equivalent to a disproof of its possibility.

The paper also contains numerical solutions to a number of other problems, including the well-known case of the circular weir-Borda flow in three dimensions. From the point of view of computational technique, these problems are among the most difficult that have been attempted by relaxation, and the authors are to be congratulated on the successful conclusion of what must have been a formidable volume of arithmetic. D. G. CHRISTOPHERSON

* *Phil. Trans. Roy. Soc.*, A, **240**, 117 (1946). "Relaxation Methods Applied to Engineering Problems. XII. Fluid Motions Characterised by Free Stream-lines", by Dr. R. V. Southwell, F.R.S., and G. Vaisey.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Tuesday, March 18

ROYAL SOCIETY OF ARTS, DOMINIONS AND COLONIES SECTION (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. S. Herbert Frankel: "Whither South Africa?"

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Physical Chemistry Lecture Theatre, Royal College of Science, South Kensington, London, S.W.7), at 2.30 p.m.—Dr. L. Leyton and Mr. G. W. Dumbleby: "Soil Conditions and Tree Growth".*

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. E. B. Ford: "Recent Advances in Genetics".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—Prof. John Read, F.R.S.: "Historic St. Andrews and its University".

ROYAL ANTHROPOLOGICAL INSTITUTE (joint meeting with the INTERNATIONAL AFRICAN INSTITUTE, at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Mr. G. I. Jones: "The Aba Market and Ibo Distributive Trade".

INSTITUTE OF PETROLEUM, NORTHERN BRANCH (at the Engineers' Club, Albert Square, Manchester), at 6 p.m.—Dr. Whalley: "Progress on the Synthesis of Fuels and Lubricants".

CHEMICAL SOCIETY, NOTTINGHAM SECTION (in the Large Chemistry Theatre, University College, Nottingham) at 7 p.m.—Dr. A. E. Alexander: "The Application of Surface Chemistry to Colloidal Problems" (Tilden Lecture).

ROYAL INSTITUTE OF CHEMISTRY, MANCHESTER SECTION (at the Grand Hotel, Manchester), at 7 p.m.—Sir Henry Dale, O.M., F.R.S.: "Chemistry and Medicinal Treatment" (Dalton Lecture).

SOCIETY OF DYERS AND COLOURISTS, HUDDERSFIELD SECTION (at Field's Café, Huddersfield), at 7.30 p.m.—Dr. F. Townend: "The Use of Acids in Wool Dyeing".

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (joint meeting with the WELWYN GARDEN CITY SCIENTISTS' CLUB, at The Cherry Tree, Welwyn Garden City), at 8 p.m.—Dr. A. M. Ward: "The Training and Qualification of Chemists".

Wednesday, March 19

PHYSICAL SOCIETY (in the New Physics Lecture Theatre, The University, Manchester), at 10 a.m.—Conference on "Meteors, Comets and the Radio Detection of Meteors" (Fellows of the Royal Astronomical Society are invited).

PHYSICAL SOCIETY, LOW-TEMPERATURE GROUP (at the Clarendon Laboratory, Parks Road, Oxford), at 11 noon–1 p.m.—Survey of the Work of the Low-Temperature Department of the Clarendon Laboratory; at 2 p.m.–3.45 p.m.—Short Talks on Selected Topics and Tour of the Laboratory.

BRITISH SOCIETY FOR INTERNATIONAL BIBLIOGRAPHY (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 2.30 p.m.—Beginners' Questions on the Use of the Universal Decimal Classification Answered.

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (joint meeting with the LONDON BRANCH of the INSTITUTE OF PHYSICS, at the Royal Institution, Albemarle Street, London, W.1), at 2.30 p.m.—Prof. E. K. Rideal, F.R.S.: "Monomolecular Layers".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 3 p.m.—Annual General Meeting. Dr. A. E. Trueman, F.R.S.: "Stratigraphical Problems in the Coalfields of Great Britain" (Presidential Address).

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at Faraday Building, 9th Floor, South Block, Knightrider Street, London, E.C.4), at 5 p.m.—Mr. W. J. Ford: "A Review of Compressed Air Technique and its Practical Application".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 5 p.m.—Prof. Douglas Hay: "British Coal Mining and the Industrial Revolution, with special reference to the Life and Work of the late Lord Cadman" (Cadman Memorial Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Dr. L. F. Broadway, Dr. C. J. Milner, Mr. D. R. Petrie, Mr. W. J. Scott and Mr. G. P. Wright: "Velocity Modulation Valves".

SIR JOHN CASS TECHNICAL INSTITUTE (at Jewry Street, Aldgate, London, E.C.3), at 6.15 p.m.—Dr. G. M. Dyson: "The Dyson System of Indexing Organic Compounds".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at the Royal Institution, Albemarle Street, London, W.1), at 6.30 p.m.—Dr. W. G. Ogg: "A Survey of the Work of the Rothamsted Experimental Station" (members of the Agriculture Group are invited).

SOCIETY OF DYERS AND COLOURISTS, MIDLANDS SECTION (at the King's Head Hotel, Loughborough), at 7 p.m.—Dr. John H. Hill: "The Chemistry and Application of Detergents".

Thursday, March 20

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 12 noon.—Annual General Meeting; at 3 p.m.—Prof. C. N. Hinshelwood, F.R.S.: Presidential Address.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. H. D. Megaw: "Temperature Changes in the Crystal Structure of Barium Titanium Oxide"; Mr. C. W. Bunn and Mr. E. V. Garner: "The Crystal Structure of Two Polyamides ('Nylons')".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. A. Ostrowski: "The Different Types of Convergence in Formal and Numerical Analysis".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. A. W. Groves: "Results of Magnetometric Survey at Benallt Manganese Mine, Rhiw, Caernarvonshire"; Messrs. A. King, A. Clemes and H. E. Cross: "The Treatment of Gold Ore containing Pyrrhotite at the Sub Nigel, Ltd.".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. E. P. G. Wright: "The Modernization of the International Telephone Service and its Reaction on National Telephone Systems".

INSTITUTE OF FUEL, NORTH-WESTERN SECTION (at Radiant House, Bold Street, Liverpool), at 6.30 p.m.—Mr. F. Aldred: "Water Treatment".

CHEMICAL SOCIETY, ABERDEEN SECTION (joint meeting with the LOCAL SECTION of the ROYAL INSTITUTE OF CHEMISTRY, in the Chemistry Department, Marischal College, Aberdeen), at 7.30 p.m.—Prof. E. L. Hirst, F.R.S.: "Recent Developments in the Chemistry of Starch and Glycogen".

ROYAL MICROSCOPICAL SOCIETY (joint meeting with the ELECTRON MICROSCOPE GROUP of the INSTITUTE OF PHYSICS, in the Great Hall of B.M.A. House, Tavistock Square, London, W.C.1), at 7.30 p.m.—Mr. J. Smiles: "Survey of the Inter-relationship of Microscopical Techniques".*

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at the Royal Army Medical College, Millbank, London, S.W.1), at 8 p.m.—Laboratory Meeting, and Demonstrations.

Friday, March 21

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department of the Imperial College, Imperial Institute Road, London, S.W.7), at 3 p.m.—Mr. W. C. Hyndi: "The Physical Properties of Glass"; Mr. T. H. Wang: "The Degree of Inhomogeneity of Optical Glass and some Aspects of its Bearing on Optical Performance".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Modern Methods of Time-Keeping" (to be opened by Sir Harold Spencer Jones, F.R.S.).*

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. M. E. Haine: "The Design and Construction of a New Electron Microscope".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Discussion on "The Combination Torque-Converter and Fluid-Coupling Drive" (to be opened by Mr. B. J. Tams and Mr. A. L. Gaties).

SOCIETY OF DYERS AND COLOURISTS, MANCHESTER SECTION (at the Gas Department Show-rooms, Manchester), at 6.30 p.m.—Mr. J. Henderson: "Temperature Range Properties of Vat Dyes on Rayon".

SOCIETY OF DYERS AND COLOURISTS, SCOTTISH SECTION (at St. Enoch Hotel, Glasgow), at 7 p.m.—Mr. J. R. F. Jackson: "Emulsions for Textiles".

ROYAL MICROSCOPICAL SOCIETY (joint meeting with the ELECTRON MICROSCOPE GROUP of the INSTITUTE OF PHYSICS, in the Great Hall of B.M.A. House, Tavistock Square, London, W.C.1), at 7.30 p.m.—Prof. W. T. Astbury, F.R.S.: "The Electron Microscope".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. D. Brunt, F.R.S.: "Where to Live—a Meteorological Problem".

Saturday, March 22

INSTITUTION OF CHEMICAL ENGINEERS, NORTH-WESTERN BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 3 p.m.—Mr. H. R. C. Pratt: "Purification and Azeotropic Dehydration of Acetonitrile".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH ASSISTANTS (3) IN ECONOMICS—The Registrar, The University, Manchester 13 (March 31).

LECTURER IN ANCIENT PHILOSOPHY—The Secretary, The University, Edinburgh (March 31).

HEAD OF THE DEPARTMENT OF HORTICULTURE, and a LECTURER IN THE BIOLOGY DEPARTMENT, at the Essex Institute of Agriculture, Writtle—The Chief Education Officer, County Offices, Chelmsford (March 31).

LECTURER-IN-CHARGE OF THE CHEMISTRY DEPARTMENT, and a LECTURER-IN-CHARGE OF THE MECHANICAL ENGINEERING DEPARTMENT, in the Technical Education Branch of the Department of Public Instruction, Sydney—The Official Secretary, New South Wales Government Offices, 125 Strand, London, W.C.2 (March 31).

ROBERT BLAIR FELLOWSHIPS (2) IN APPLIED SCIENCE AND TECHNOLOGY—The Education Officer (H.1/2), London County Council, County Hall, London, S.E.1 (April 1).

LECTURER IN PHYSIOLOGY, and a LABORATORY SUPERINTENDENT, at Makerere College, Kampala, East Africa—The Secretary, Inter-University Council, 8 Park Street, London, W.1 (April 1).

LECTURER IN CHEMISTRY AND SOIL SCIENCE at the College in Trinidad—The Secretary, Imperial College of Tropical Agriculture, Grand Buildings, Trafalgar Square, London, W.C.2 (April 7).

READERSHIP IN PSYCHOLOGY tenable at the Institute of Education—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 24).

ENTOMOLOGIST with special interest in and knowledge of the Coleoptera, and an ENTOMOLOGIST with special interest in and knowledge of the Hymenoptera—The Director, Imperial Institute of Entomology, 41 Queen's Gate, London, S.W.7 (June 1).